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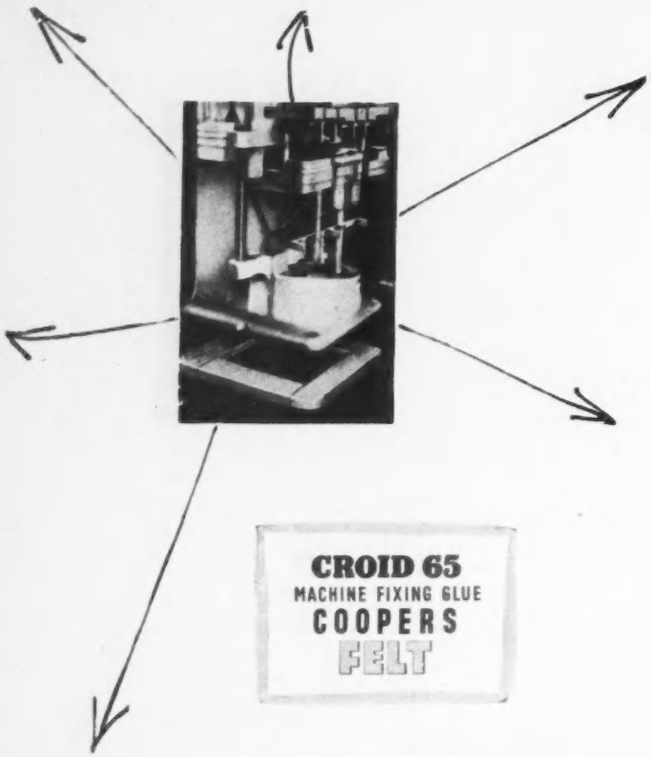

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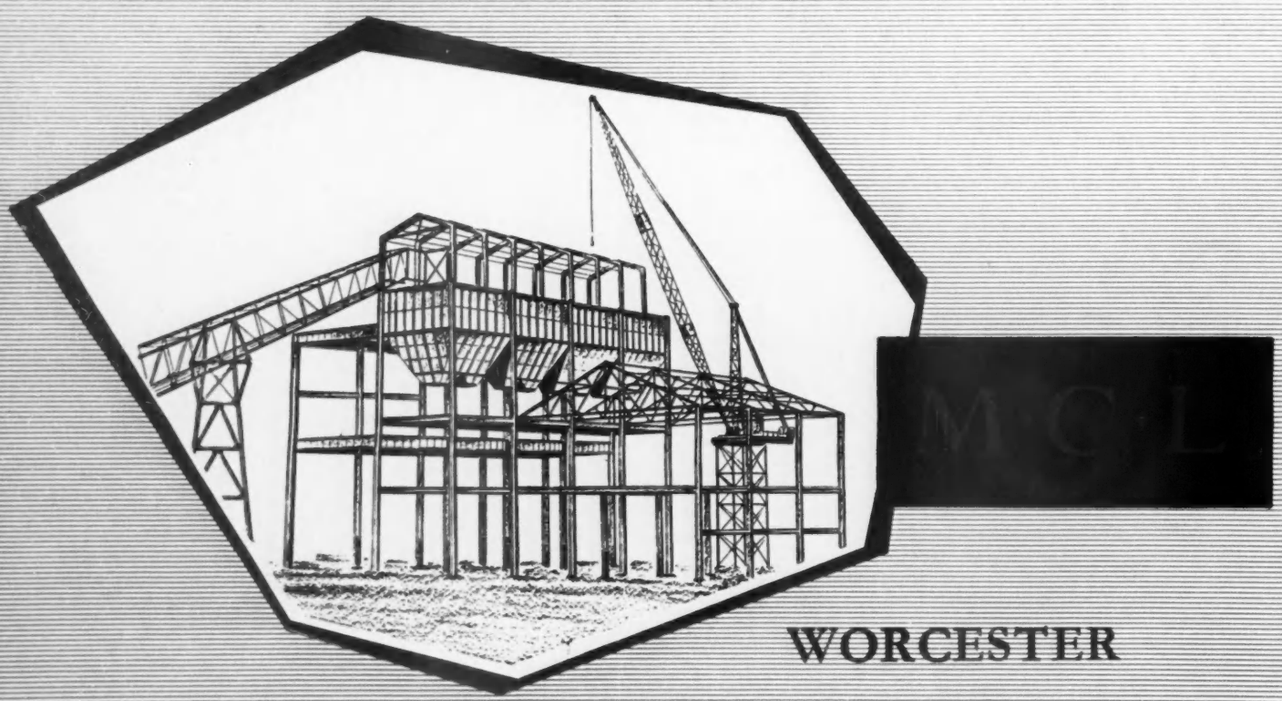

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THE ENGINEER

Established 1856

No. 5404 **AUGUST 21, 1959** VOL. 208

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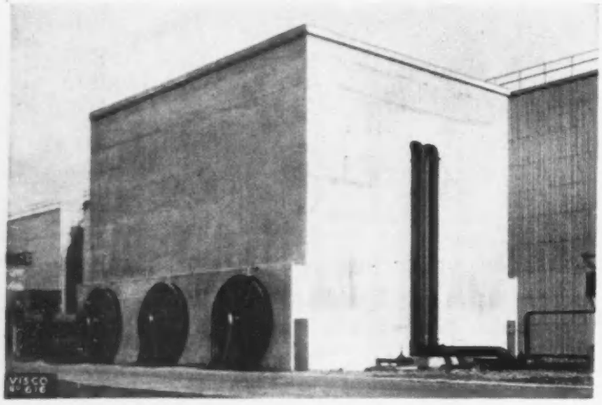

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To: Publicity Manager

Subject: CONTROL GEAR PUBLICITY

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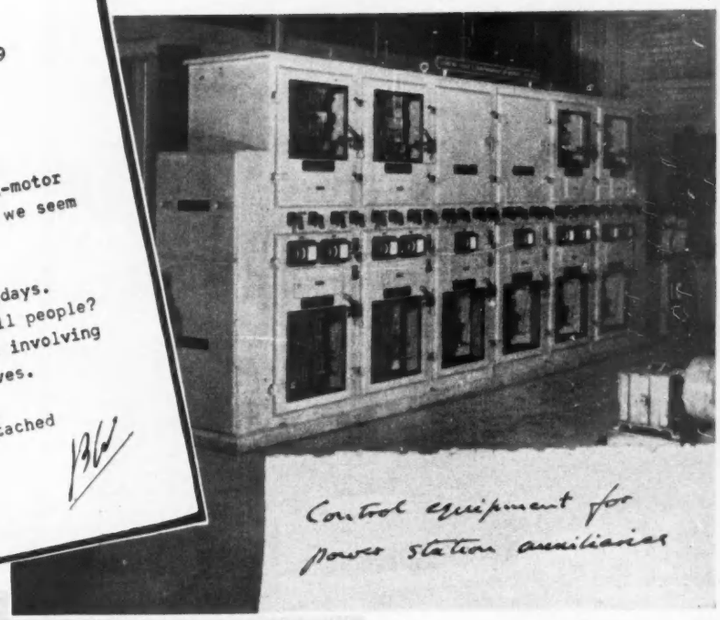
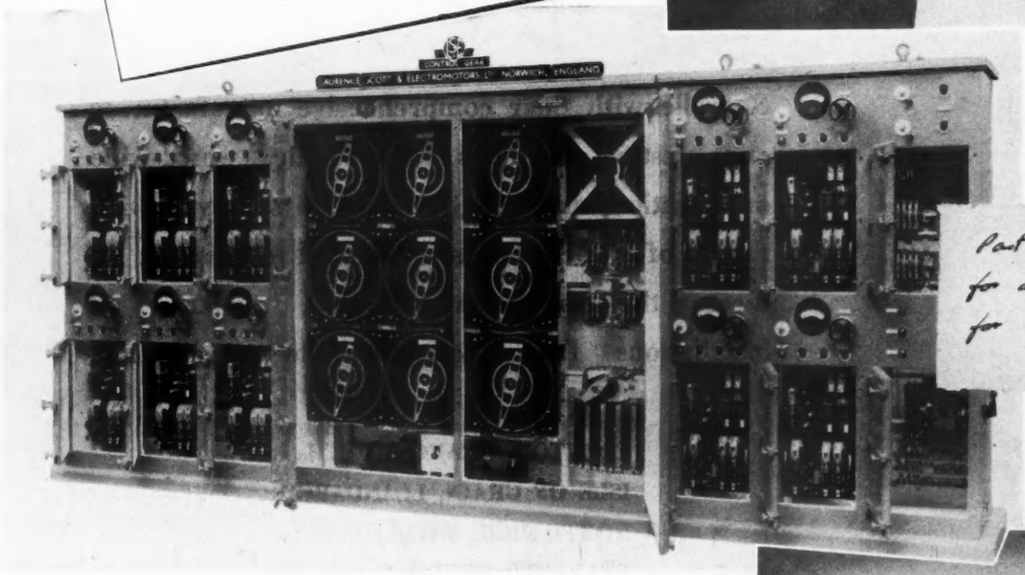
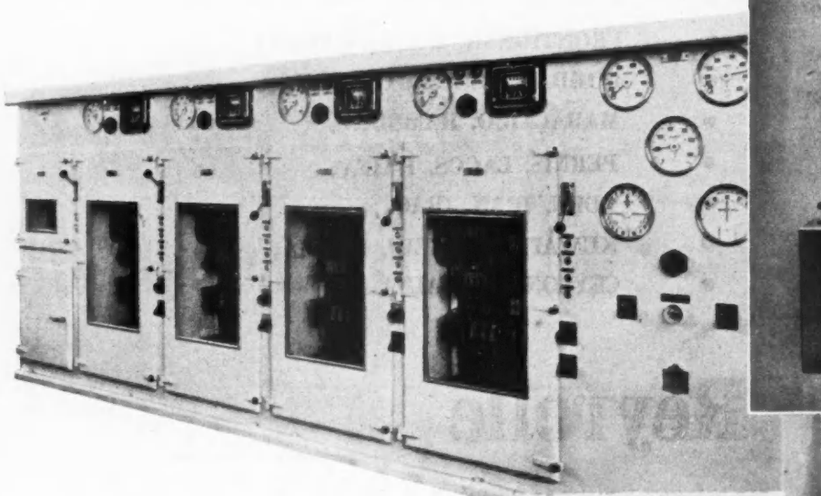


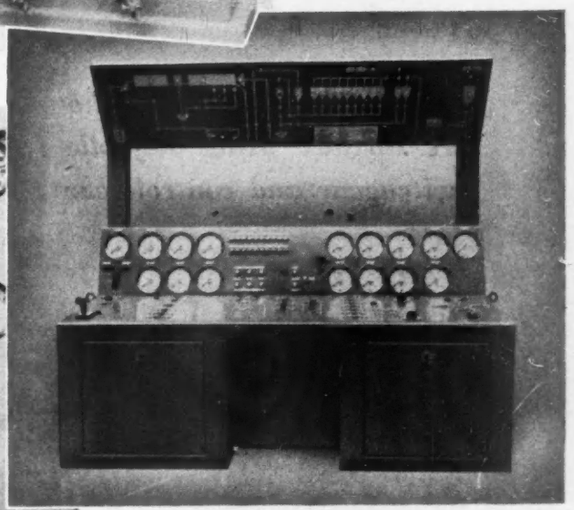
Control equipment for power station auxiliaries



Part of the control gear for about 70 H.P. motors for a Sintering plant



One of many waterworks jobs



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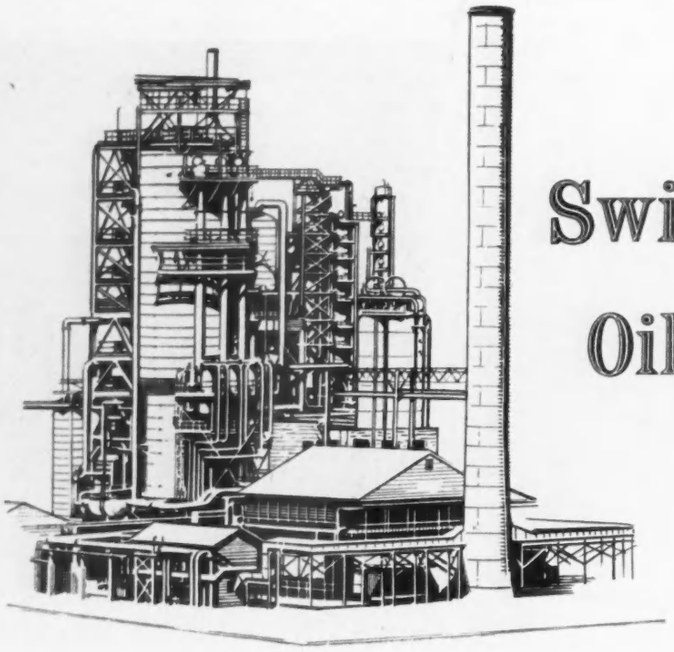

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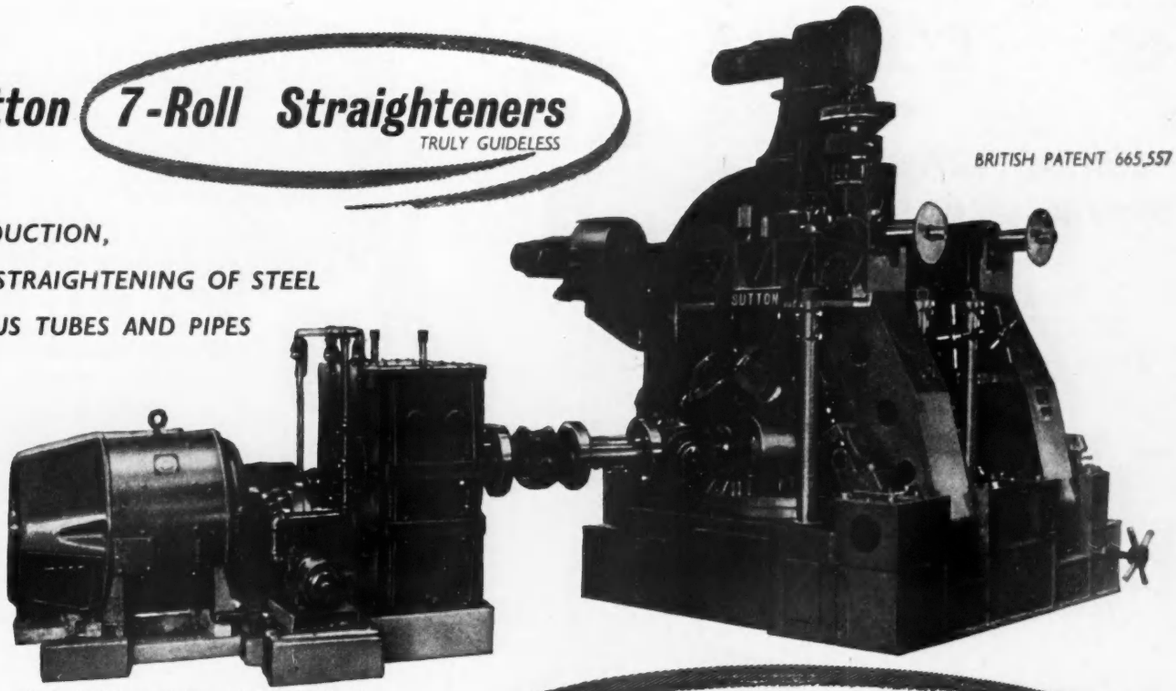

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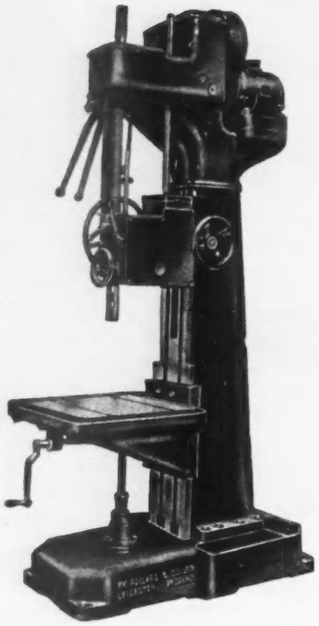

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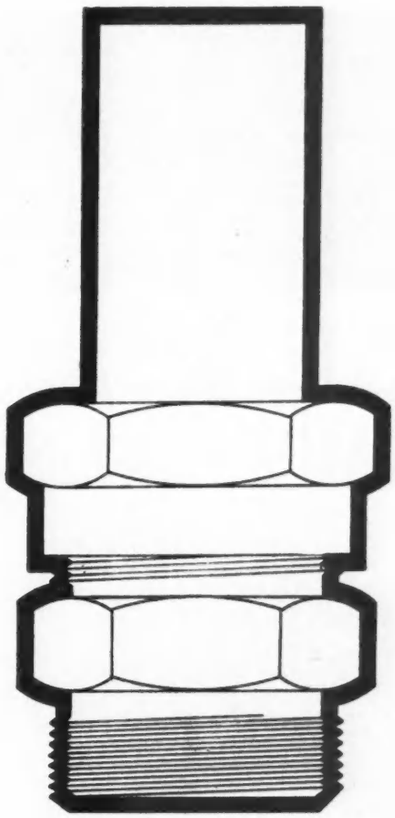

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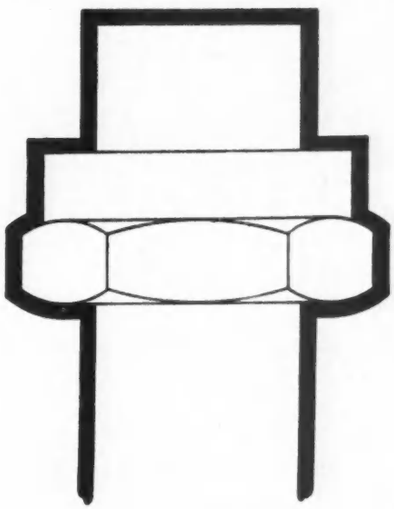

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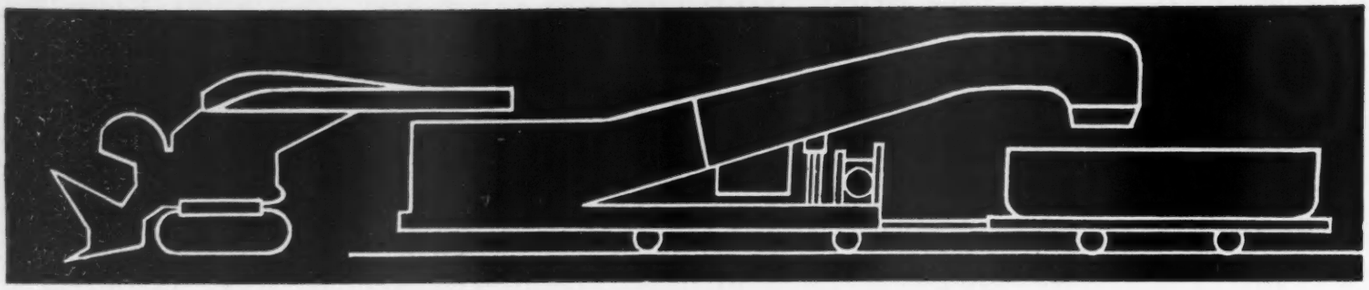

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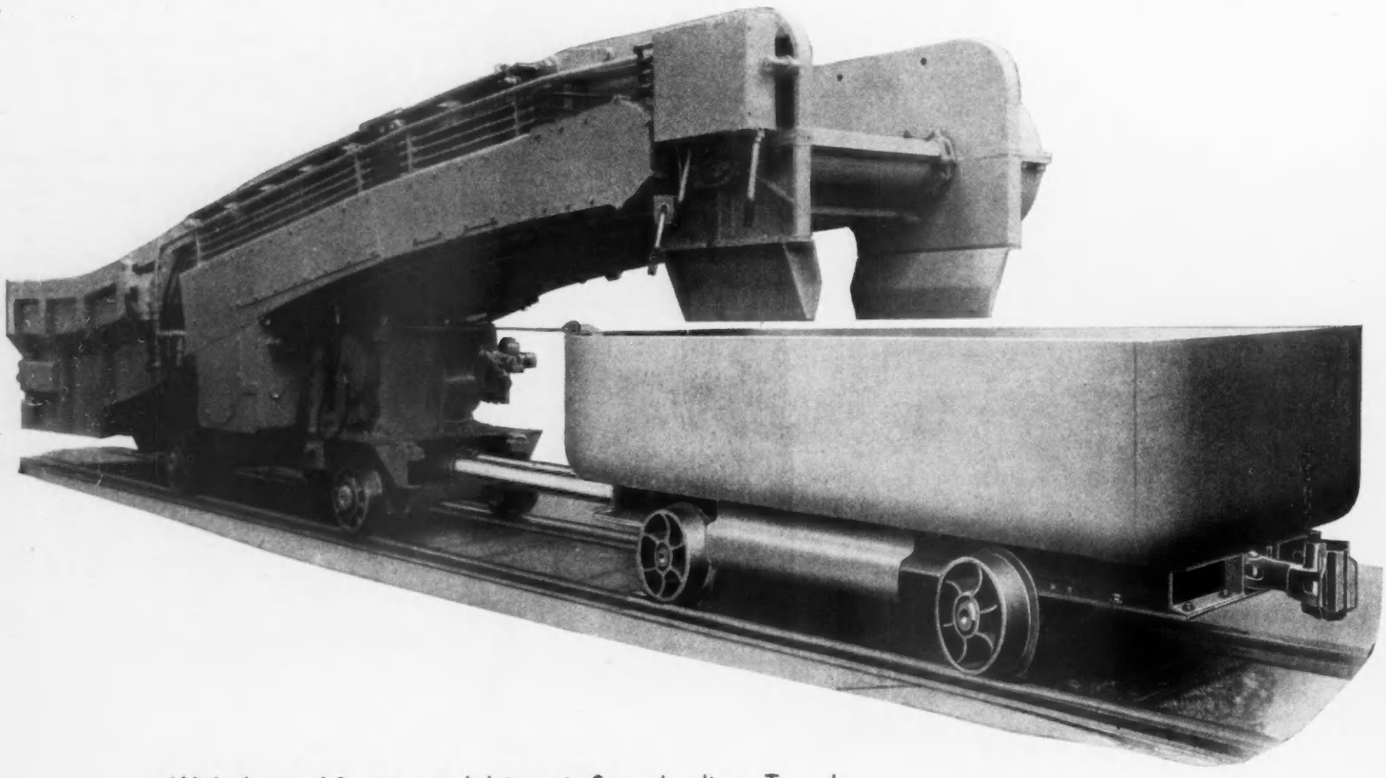

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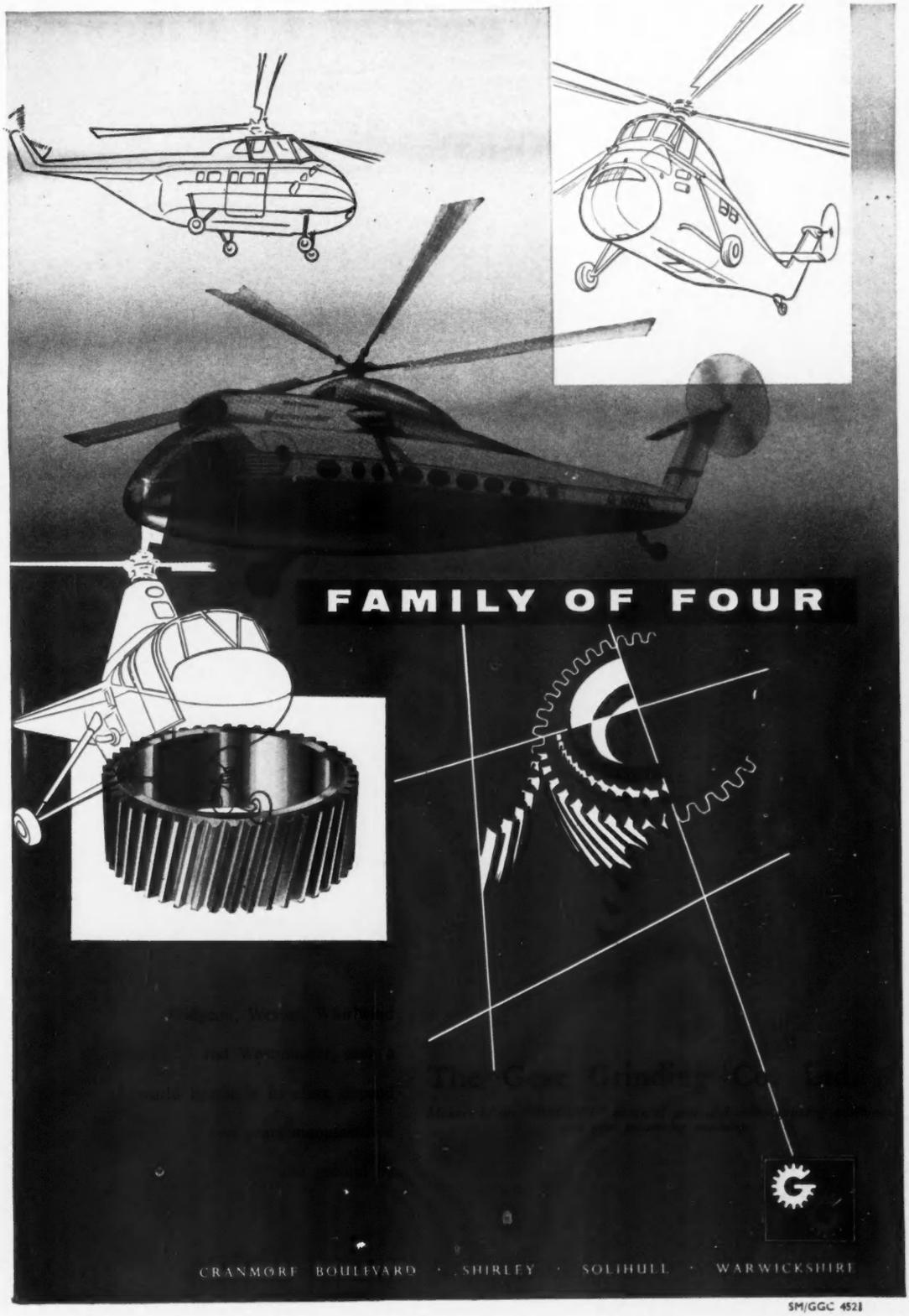
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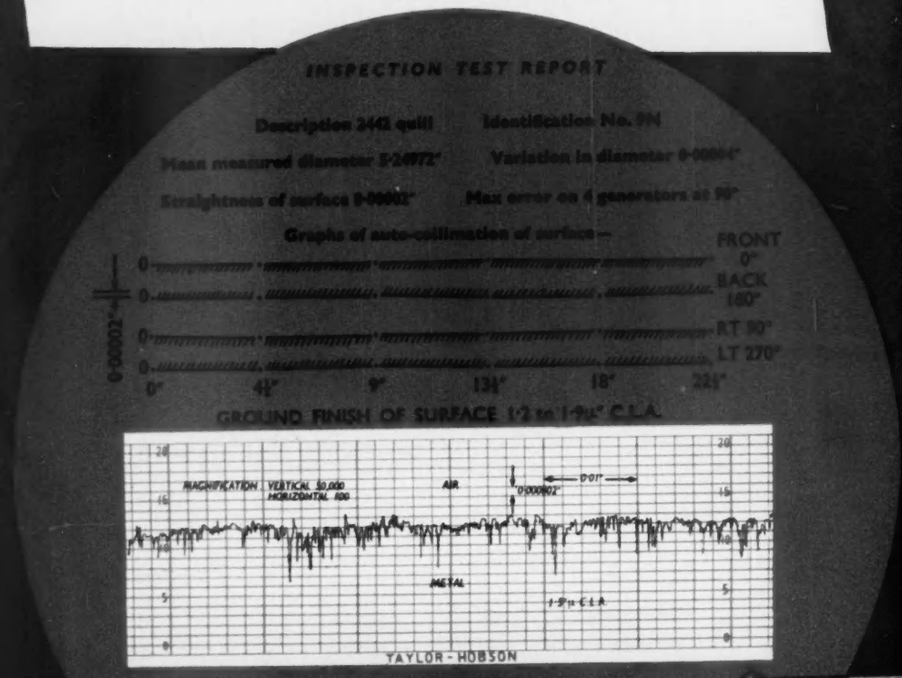

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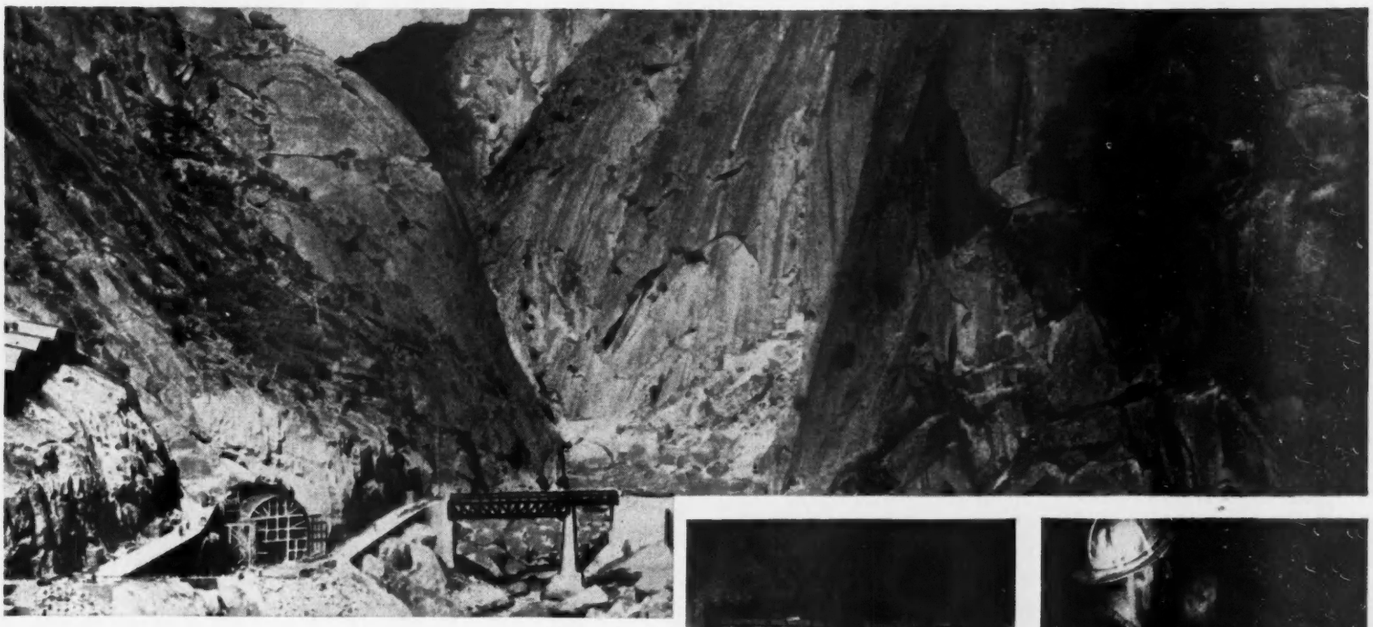

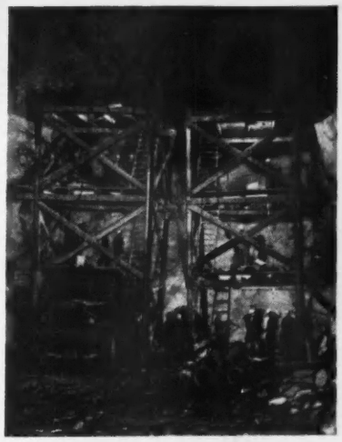

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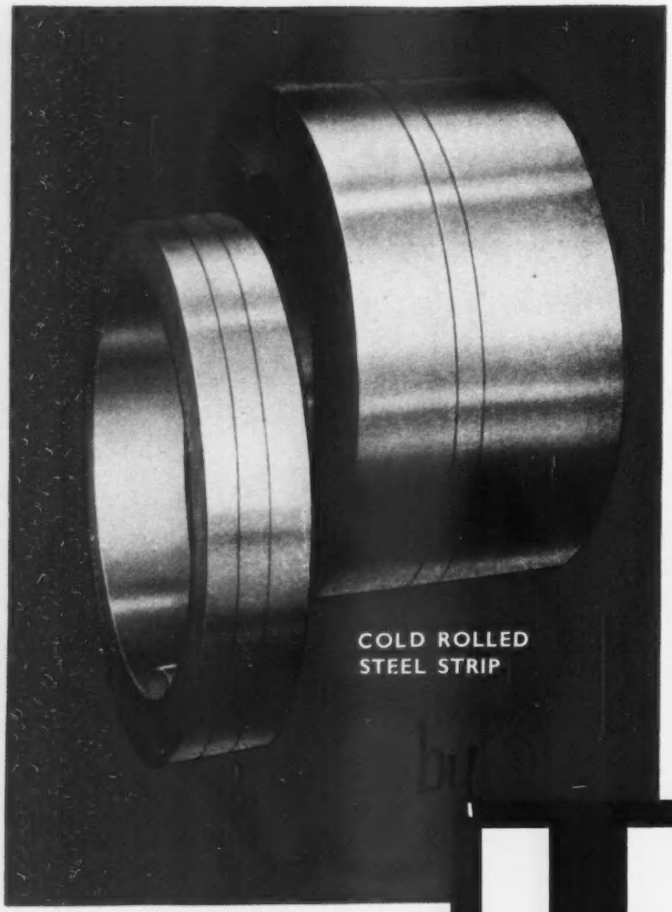

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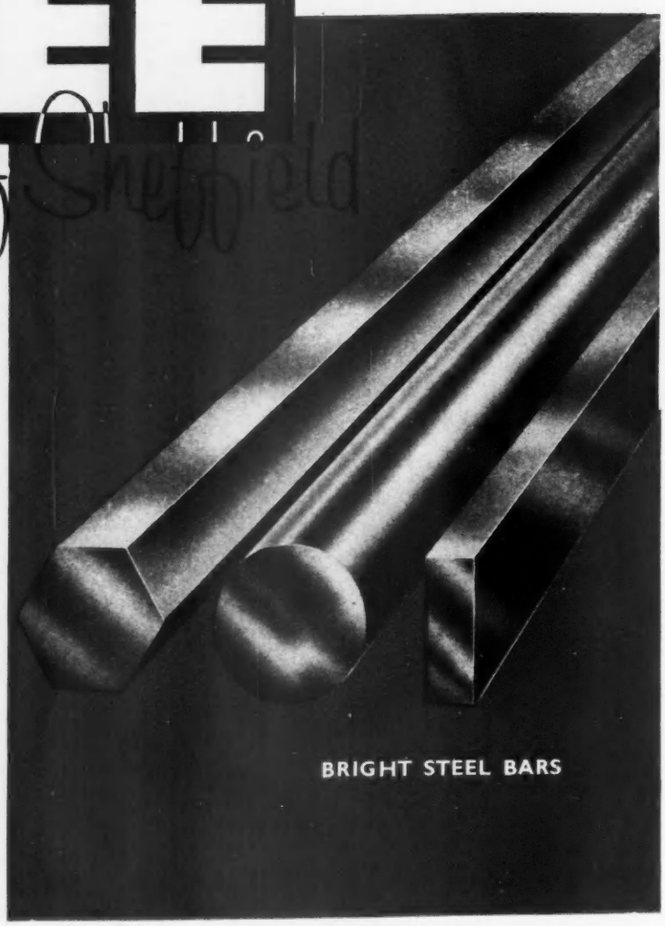

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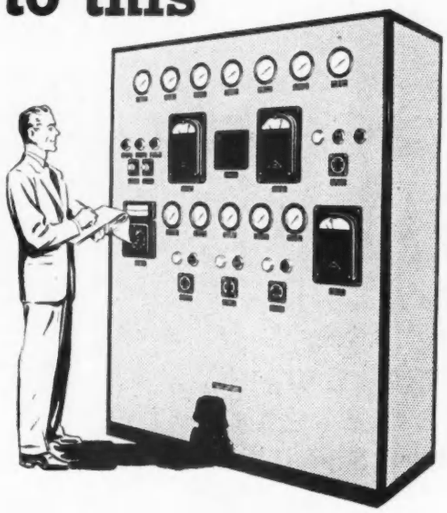

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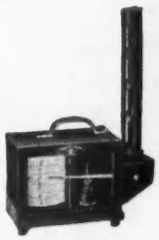

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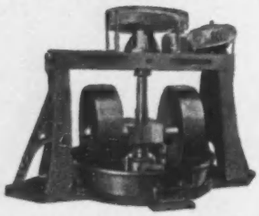

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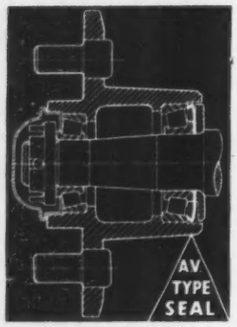

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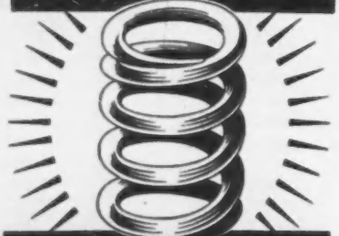

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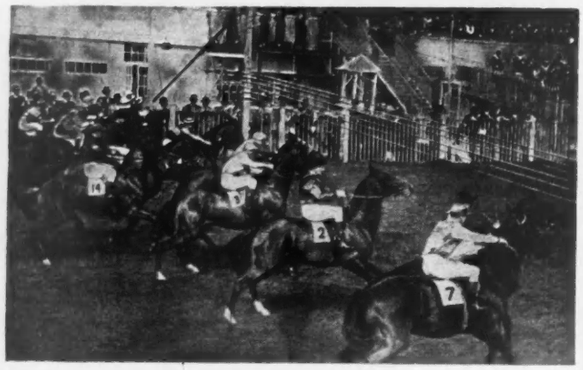
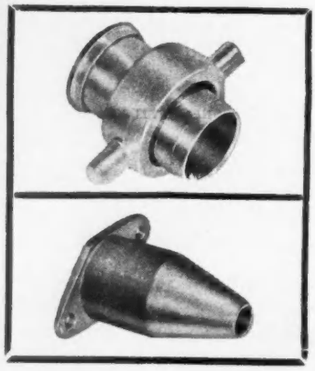


The choice is often difficult



May we pick the winner for you ...

When choosing between Die Castings or Hot Pressings you can count on us for sound, unbiased advice! We make both HOT PRESSINGS in *Brass, Bronze, Copper or Aluminium* and GRAVITY DIE CASTINGS in *Brass, Bronze or Aluminium*. The unique experience of our organisation ... two separate yet inter-related operations under one roof ... will ensure that your choice is correct. For a constant or phased supply of DIMENSIONALLY ACCURATE PARTS in *Brass, Bronze, Copper or Aluminium*—see us first! Our Technical Representatives are always at your service.

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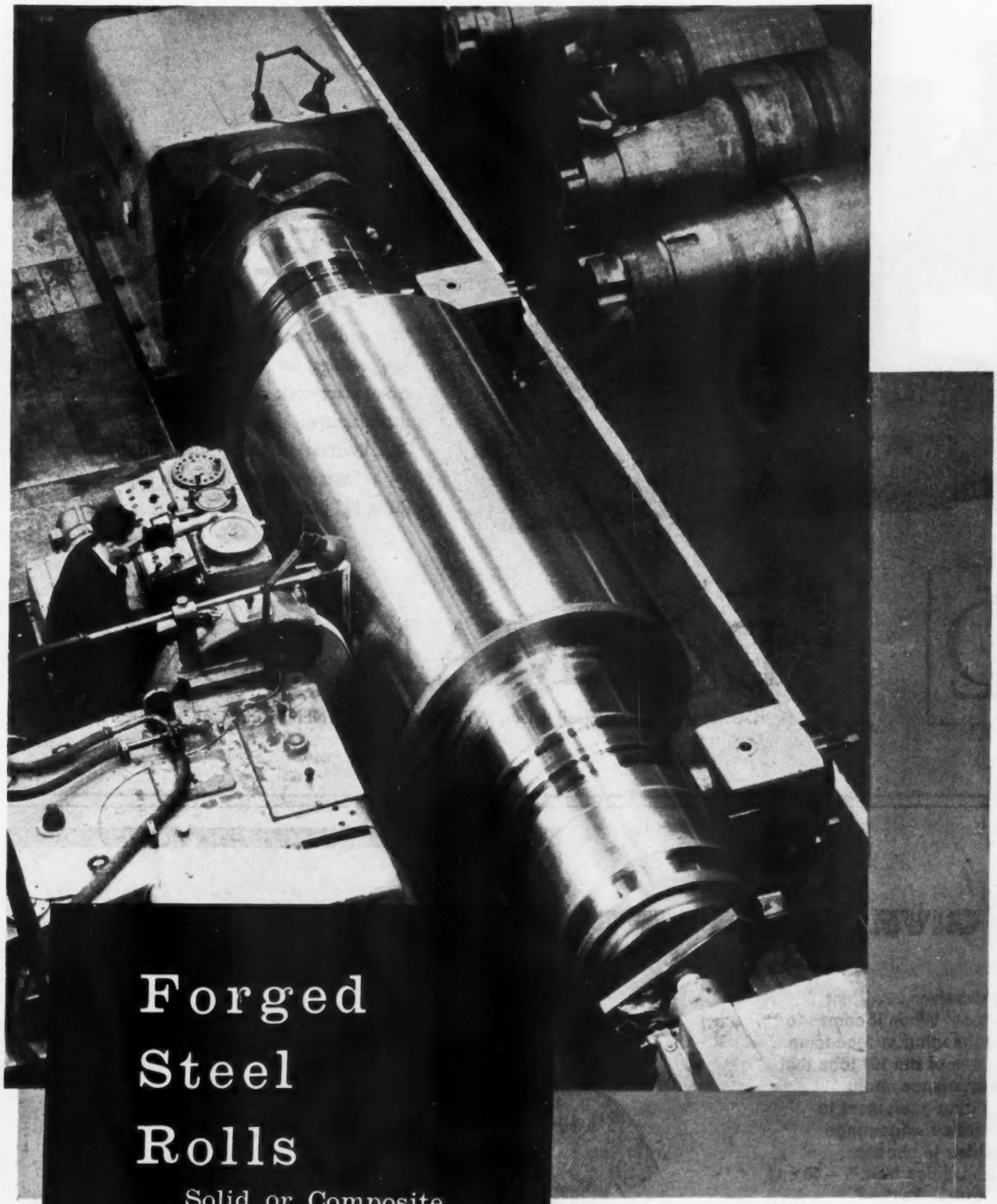

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Forged Steel Rolls, fully hardened or semi-hardened as required, and work and back-up rolls from a few pounds in weight up to 50 tons, are Firth Brown specialities.

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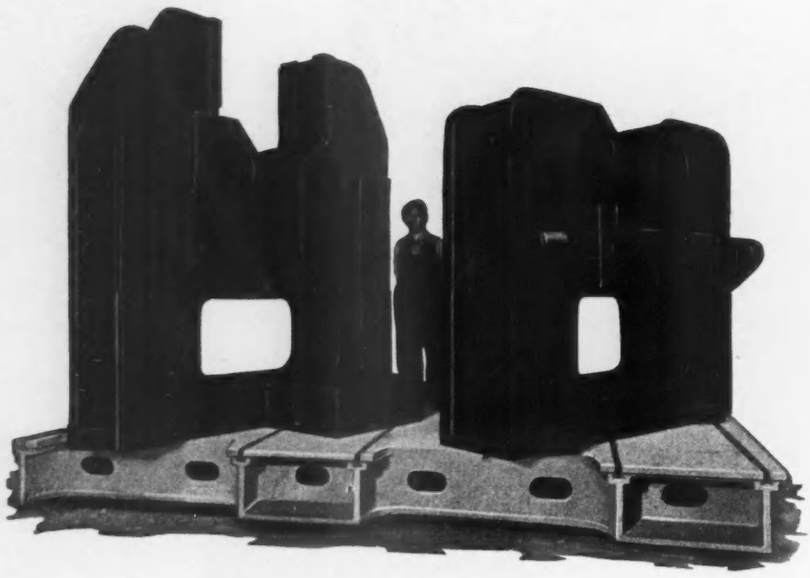

HEAVY 'WELDINGS'

We undertake the fabrication of frames and casings for heavy machines, welded from platework and sections of our own manufacture.
The illustration shows the end housings for a flattening machine with capacity for 20″ x 1½″ plates.

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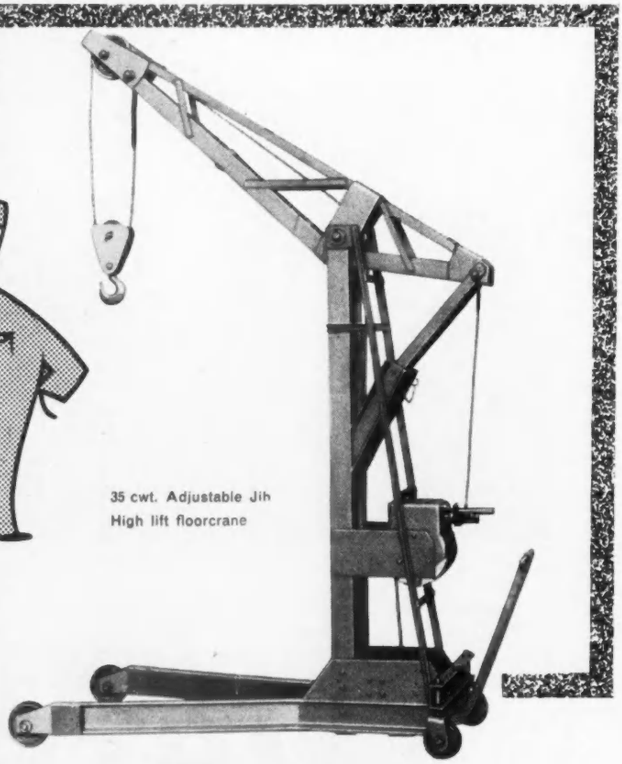

35 cwt. Adjustable Jib High lift floorcrane

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Cranes, Gantries, Cleansing tanks, Recovery equipment, Tyre remover, Miscellaneous workshop equipment.

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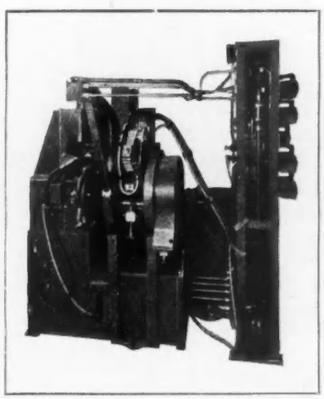
. . . and hoping that your machinery problems will work themselves out!
A far better way would be to '*talk it over with* DATIM' — for, with our long experience in Automatic machine building, we can offer an unequalled service — working to customers' own designs or providing complete design and development service in co-operation with customers engineers.



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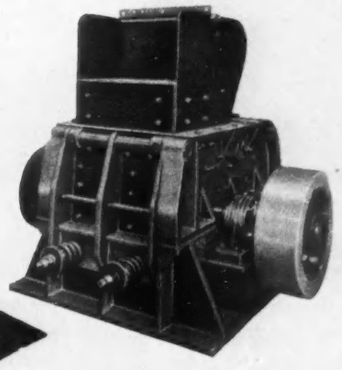
making an impact

SWINGING a hatchet to chop domestic firewood is a laborious process, not without hazards when it comes to breaking the sticks into small lengths. Breaking *industrial materials* to small sizes is the job B.J-D Crushers do—easily and safely. For example, the B.J-D Swarf Breaker reduces voluminous swarf to small pieces that can be readily shovelled—of a size, in fact, to suit the furnace (or the scrap merchant). *All the leading motor manufacturers have installed these machines.* The range of B.J-D impact crushers covers most industrial needs: indeed, the top firms in many industries use them for all kinds of unusual applications. May we tell you more about B.J-D Crushers?



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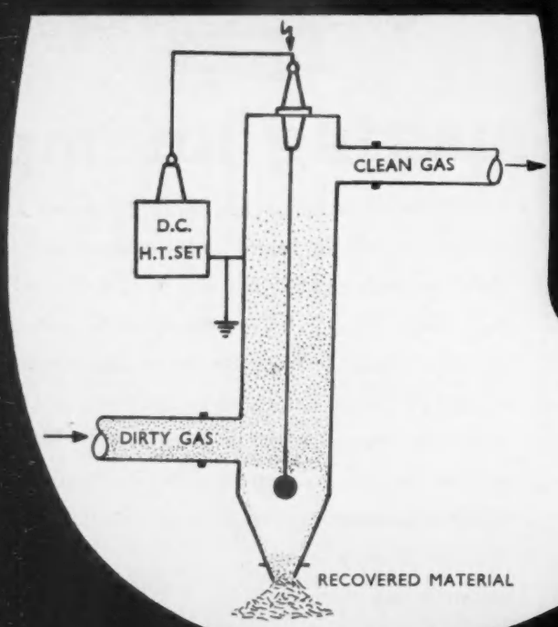

You can't afford smoke nowadays — it's bad for you and it's bad for other people too. For clean air you need the very best in electro-precipitation. That is what our vast research and development resources, backed by unrivalled experience, can give you. Pollution from the chimneys of power stations, iron and steelworks, chemical plants and other industrial plants all over the world has been cut to a minimum by our high-efficiency electro-precipitation. It's time your chimneys, too, gave up smoking!

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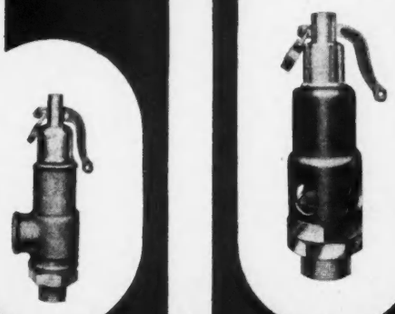

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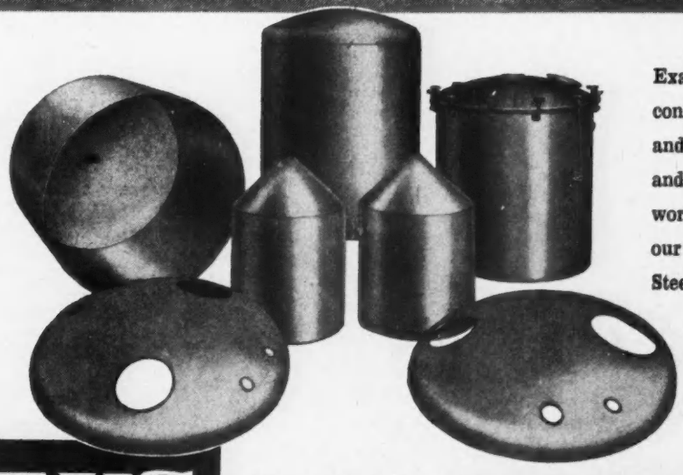

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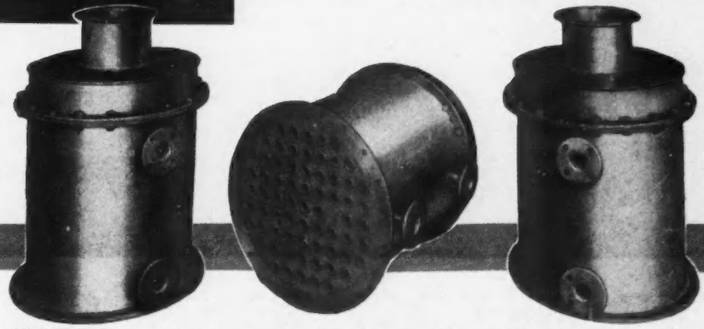

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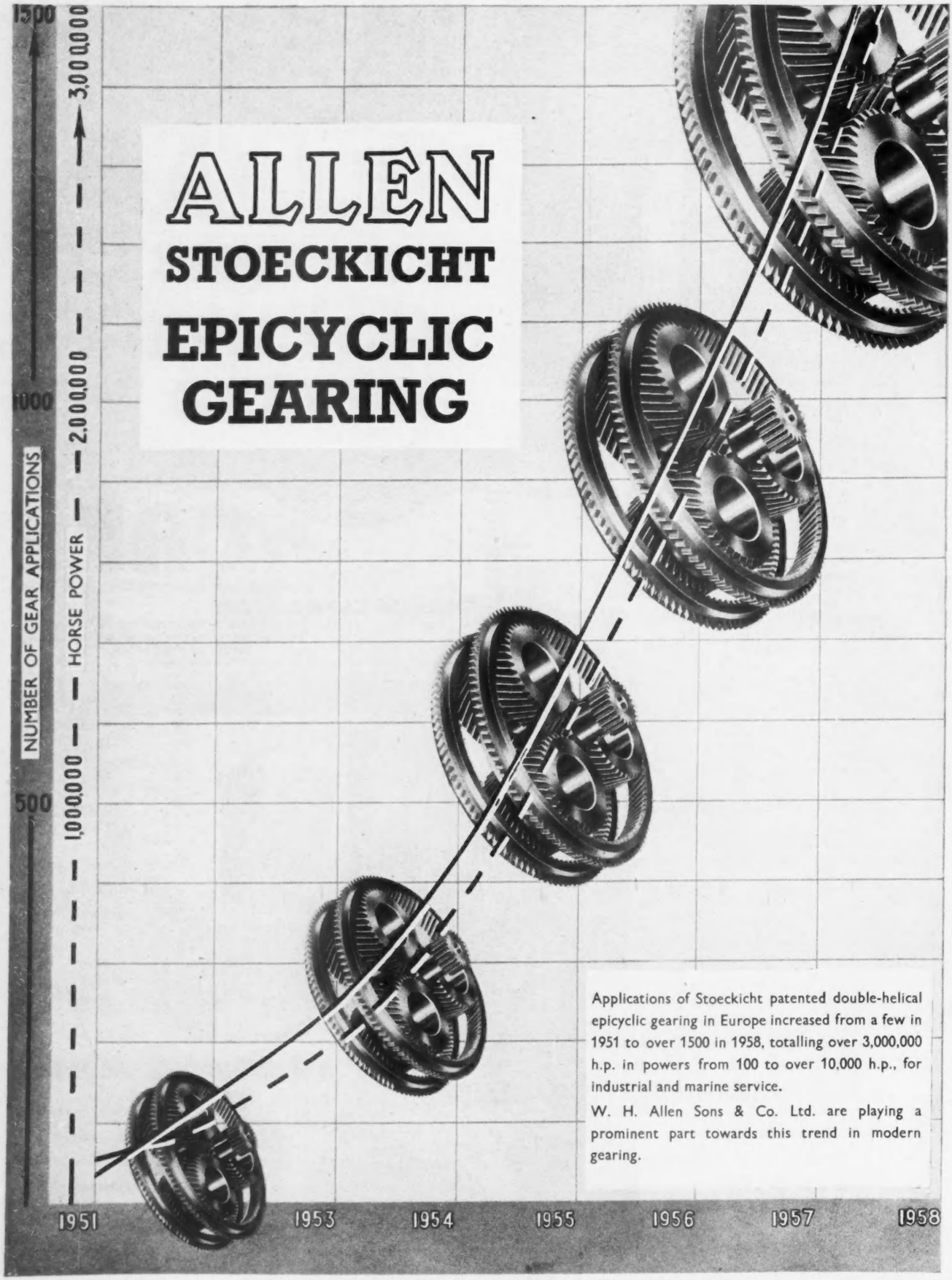

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Please address all enquiries for gearing to ATLAS WORKS, PERSHORE, Worcs.

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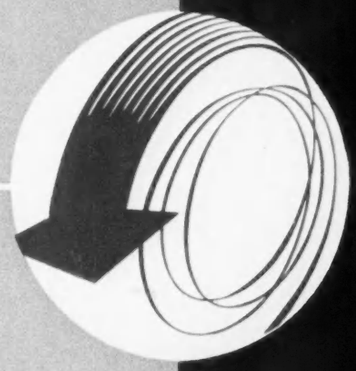

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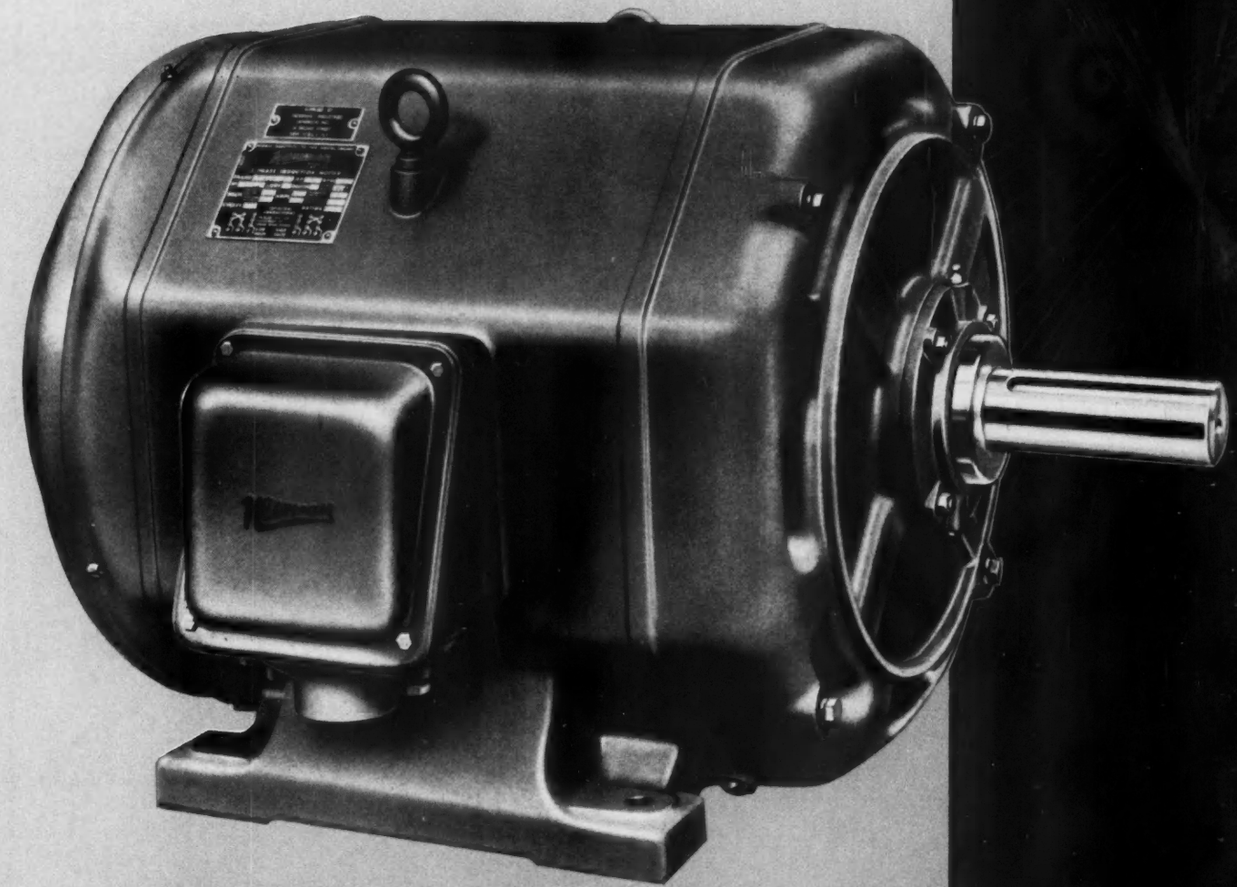

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Making the pace
in motor progress

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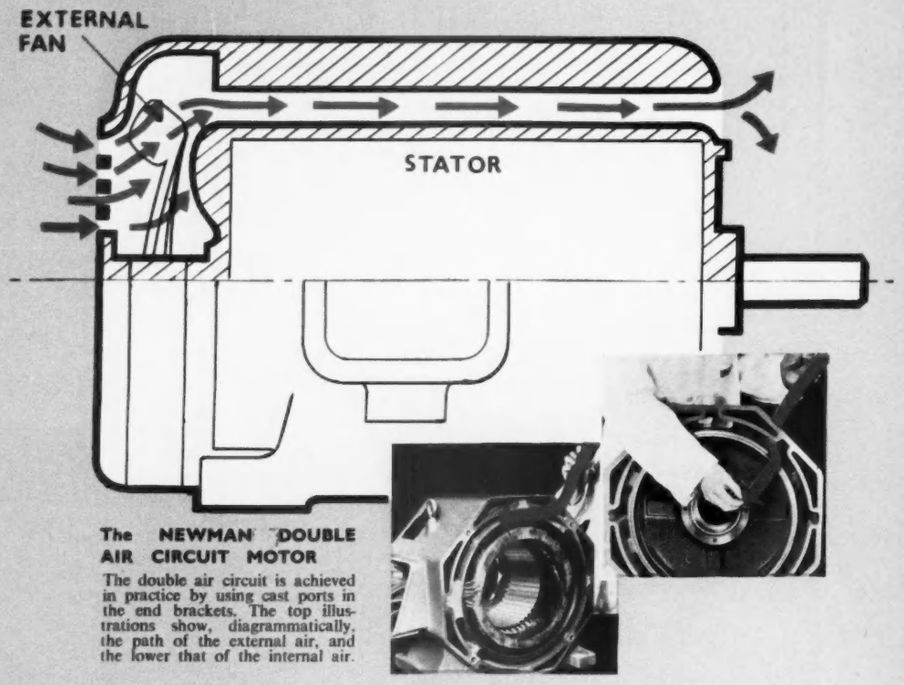
FOR MORE EFFICIENT MOTOR COOLING

Design of the ventilation and cooling system of an electric motor is of primary importance. On it depend efficient performance, economic production and dimensional compactness.

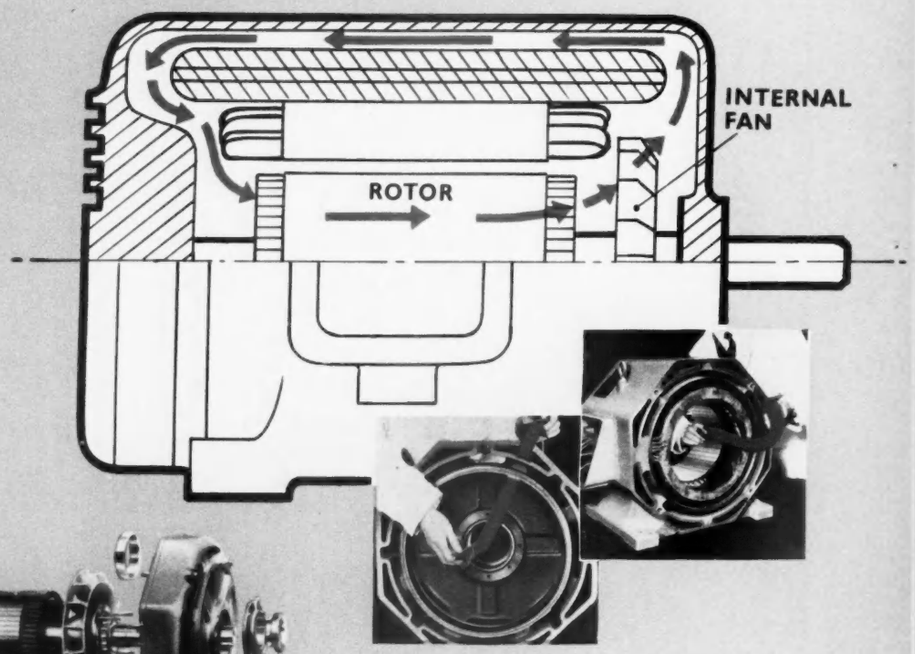
Obviously the first requisite is that the cooling system shall allow the motor to work at maximum output but at the same time keep the working temperature below the specified BS figure for the particular type of insulation. In addition it must, by virtue of its design, reduce its own 'loss' to a minimum.

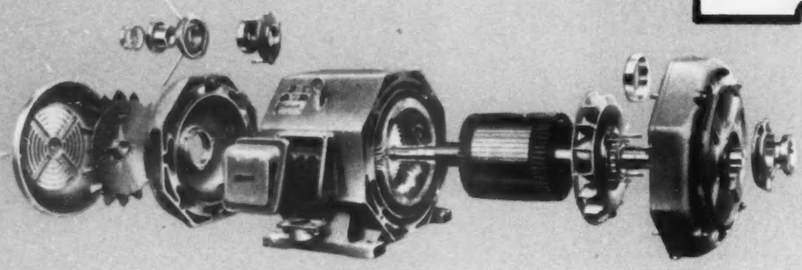
A totally enclosed motor can only be cooled by radiation or convection from the motor casing, without the hot air circulating inside the motor coming into contact with the surrounding atmosphere. Illustrated here is the Newman type J.C. totally enclosed motor which, by means of a double ventilation circuit approaches optimum cooling efficiency for this type of motor. The diagrams show how the two completely independent air circuits each with its own fan, are arranged. The cool external air is drawn in at the non-drive end and channelled close to the stator core to draw off maximum heat as it passes. The hot air inside the motor is circulated close to the outside of the stator frame to lose heat rapidly by direct radiation as well as by convection caused by the external air circuit channel underneath.

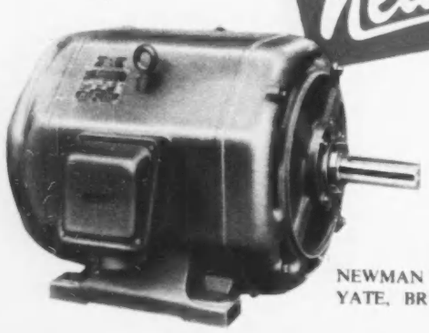


The NEWMAN DOUBLE AIR CIRCUIT MOTOR

The double air circuit is achieved in practice by using cast ports in the end brackets. The top illustrations show, diagrammatically, the path of the external air, and the lower that of the internal air.







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Electric Motors from $\frac{1}{16}$ to 600 H.P.

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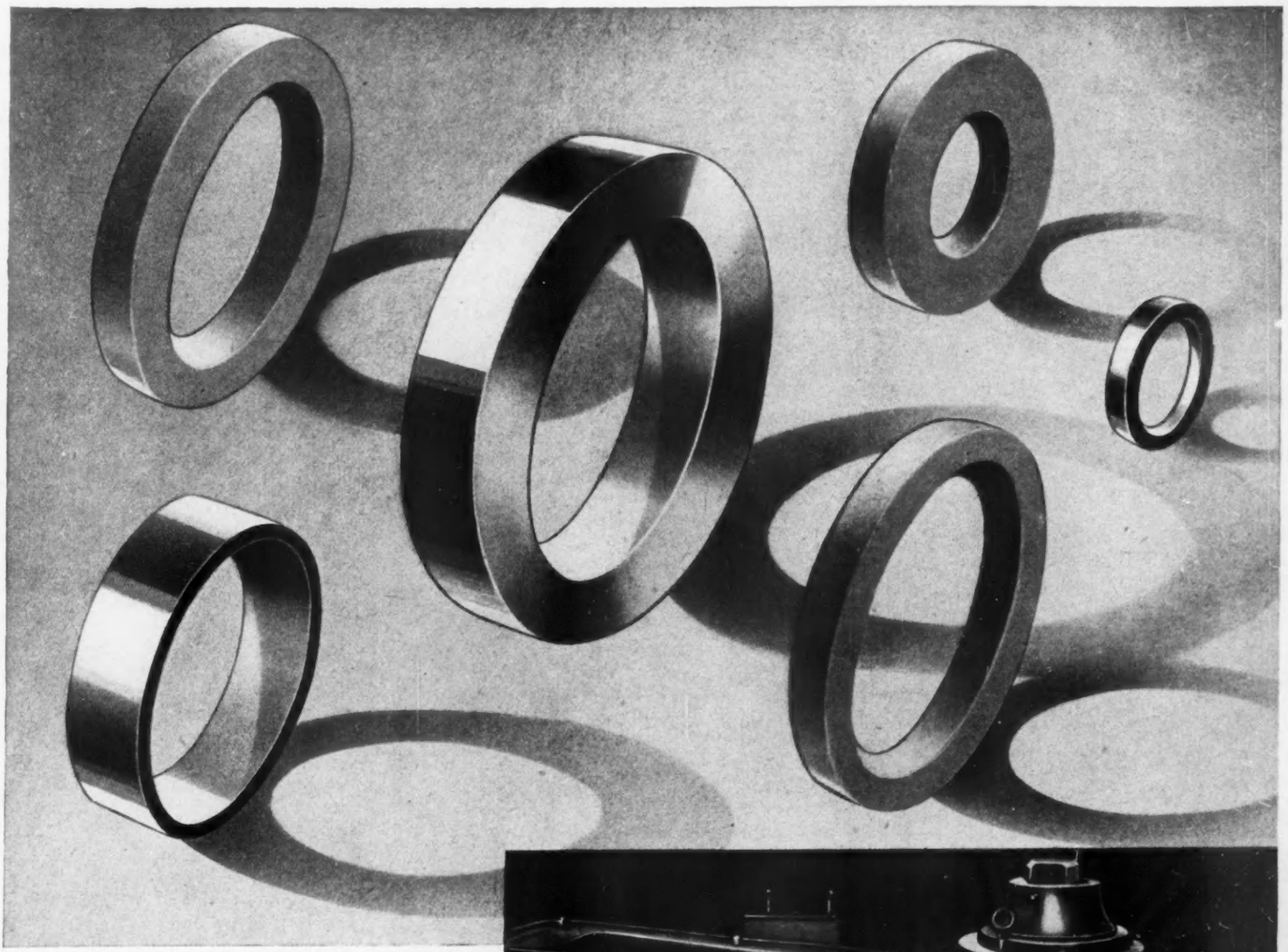

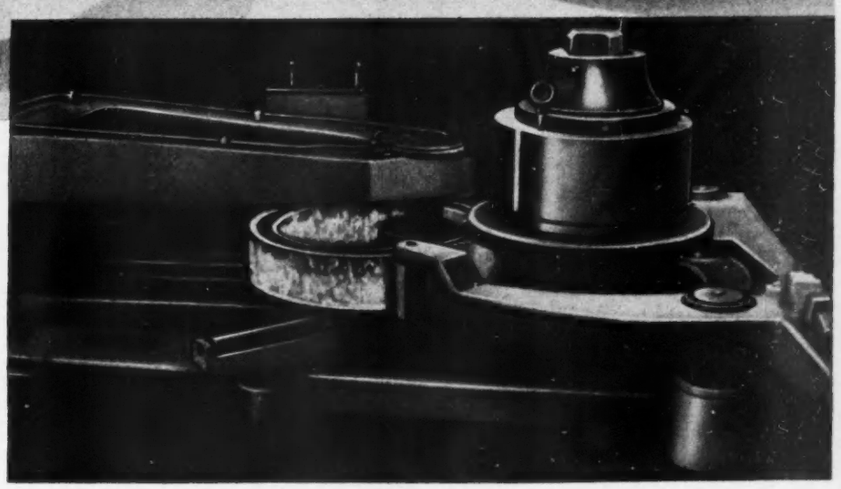

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Outputs have been greatly increased with an average of five thousand tons of steel per week.

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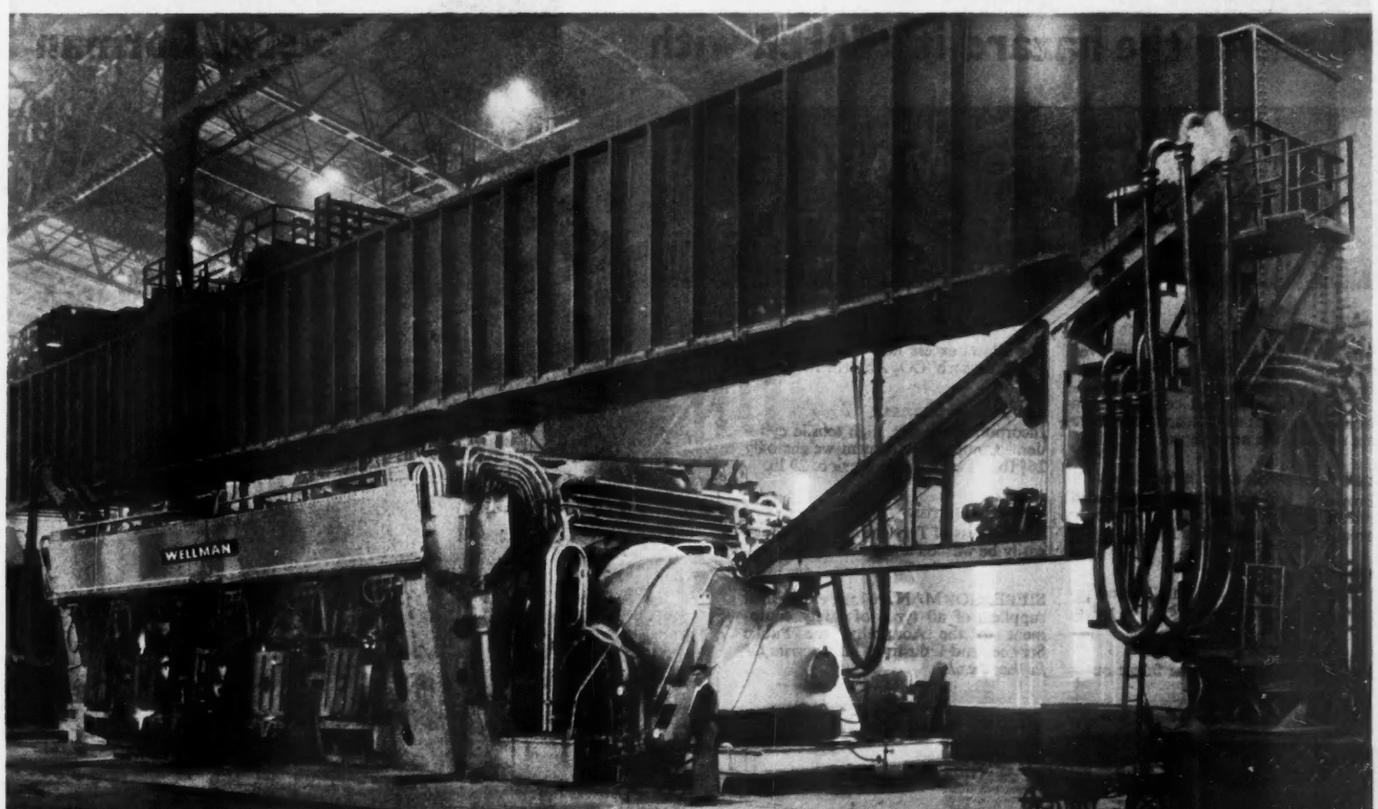
As licensees we invite you to consult us for either converting existing plant or providing new furnaces incorporating the Ajax Oxygen Steel-making Operation.



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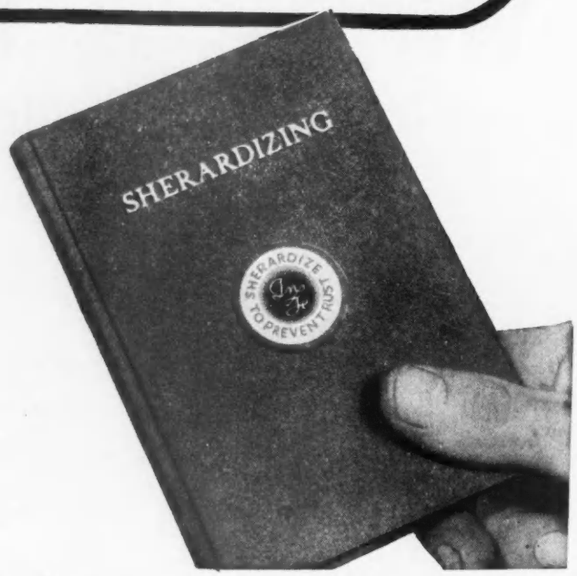

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Provided by improved spring-loaded mica disc valves and extra large-bore breathing tubes and mouth piece.

MORE COMPACT
Re-designed reducer is smaller and incorporates a push-button by-pass valve.

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Incorporates lighter, high tensile cylinder. Complete equipment weighs only 26½ lb. Two cylinder version, 29 lb.

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The harness of Terylene and Nylon may easily be washed and dries rapidly.

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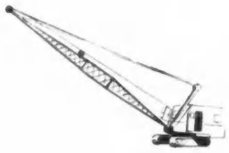

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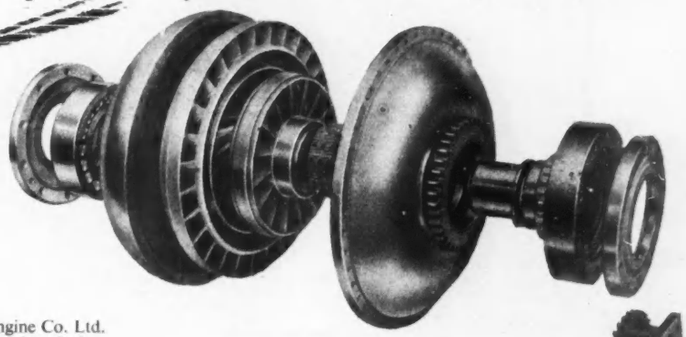
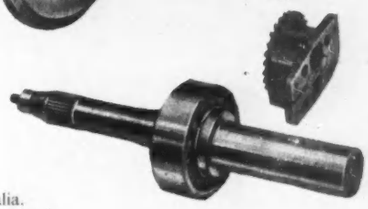
feather controlled power at your operators' fingertips



Cut your operators' fatigue and time by incorporating the **BROCKHOUSE INDUSTRIAL TORQUE CONVERTER** into your heavy equipment and enjoy a high record of efficiency and trouble-free service. Our illustrations show some of the varied applications, including aircraft towing, in which the Brockhouse Industrial Torque Converter has been used with success for many years.



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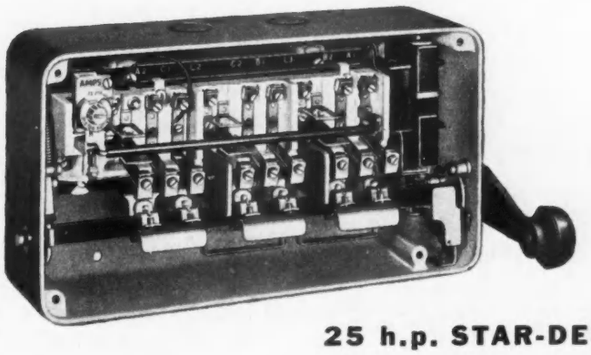
Addition to the famous range



Other features include :—

Adjustable load indicator; positive no-volt release action, even with a fading voltage.

Laminated silver-copper fixed contacts; heavy gauge copper moving contacts, all readily accessible for inspection and cleaning.

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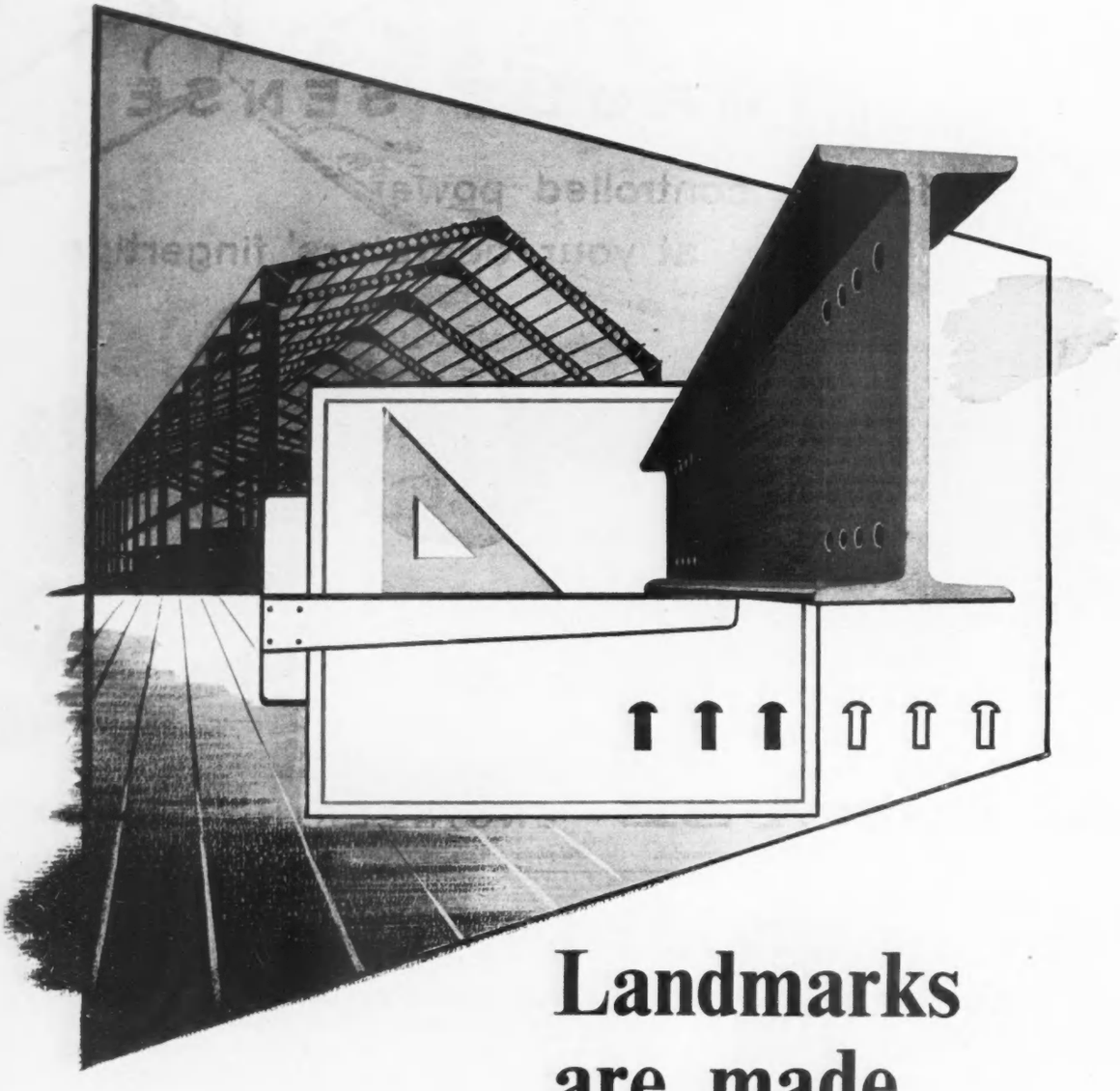

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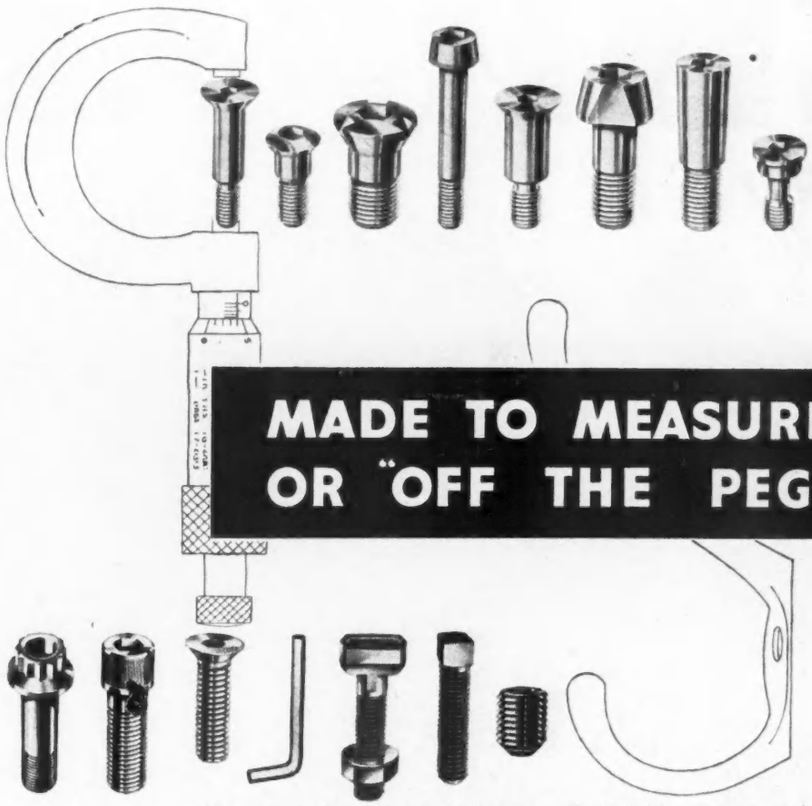

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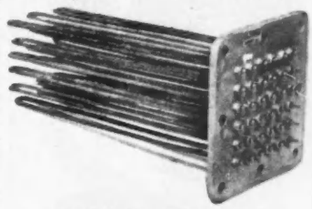

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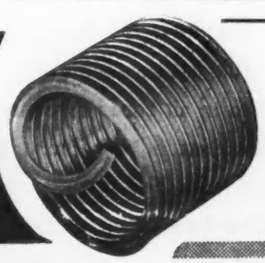

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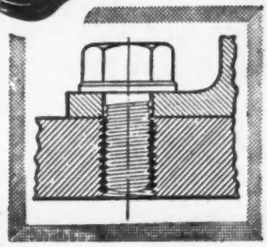

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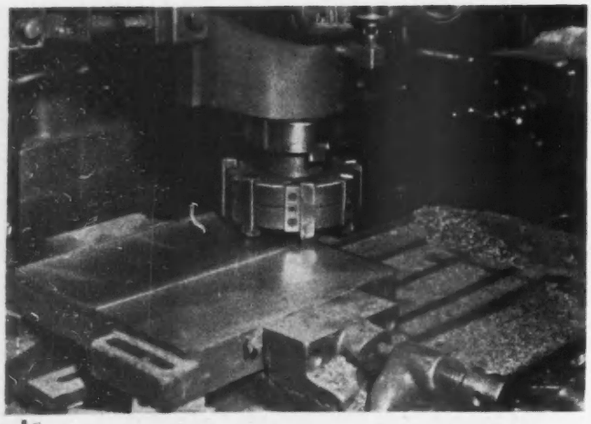

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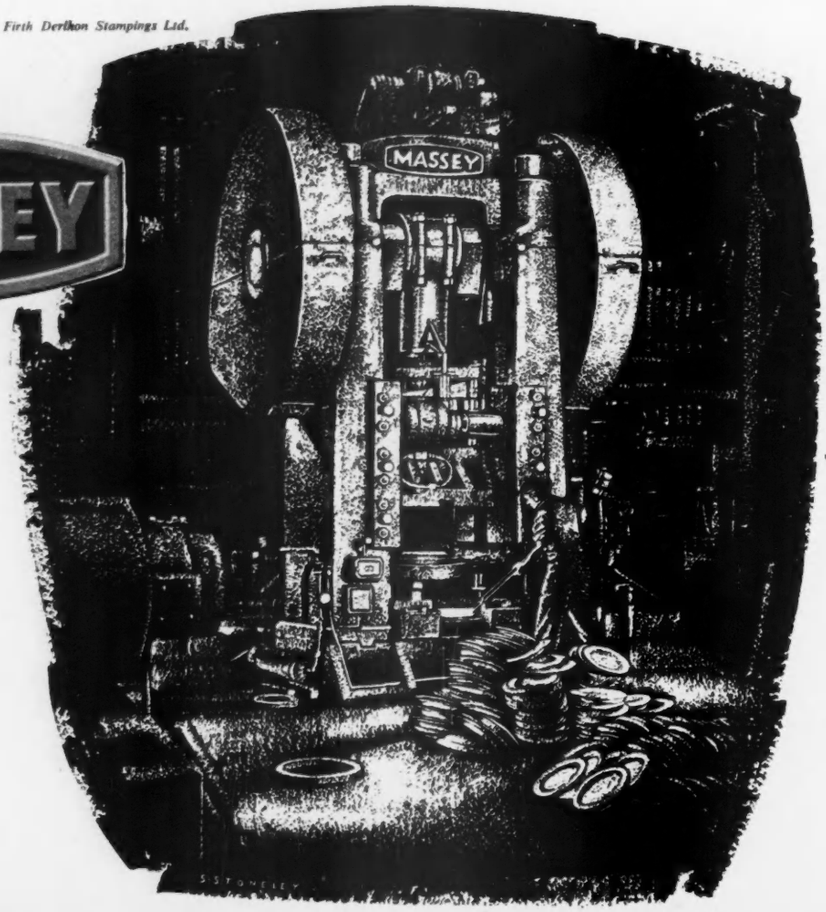

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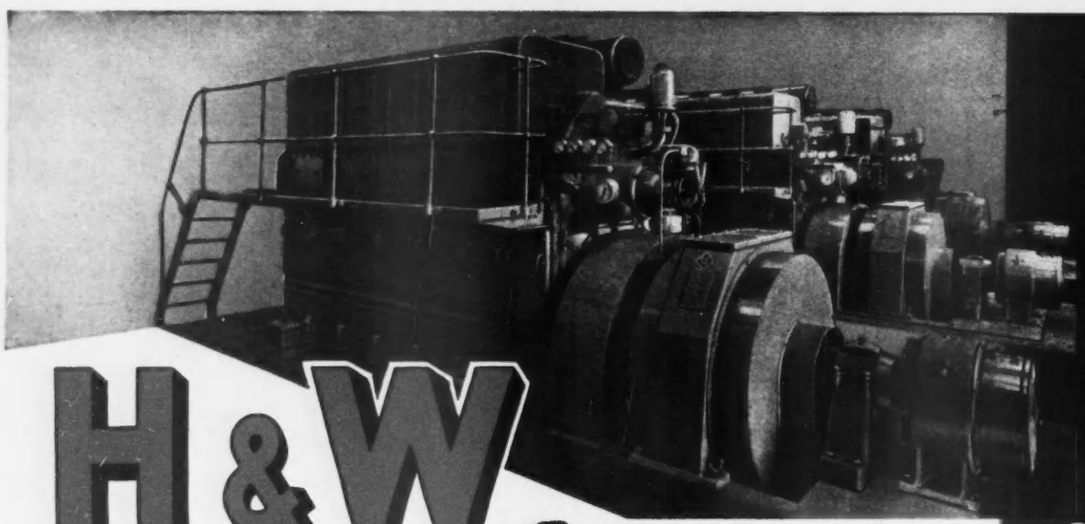

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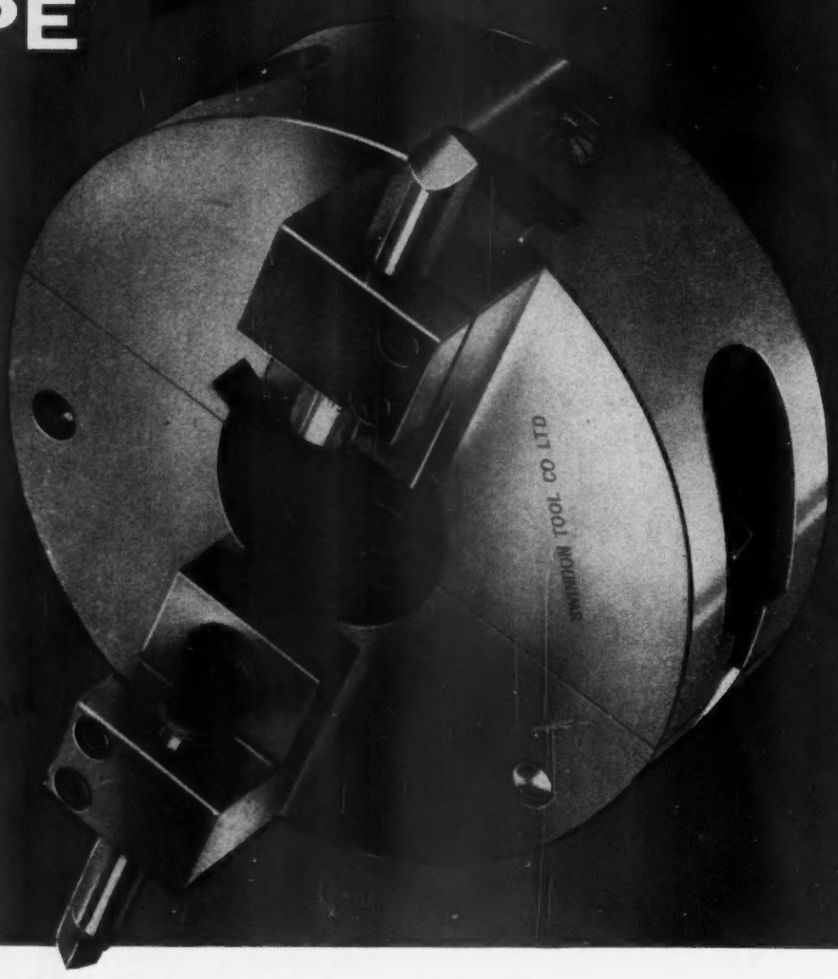

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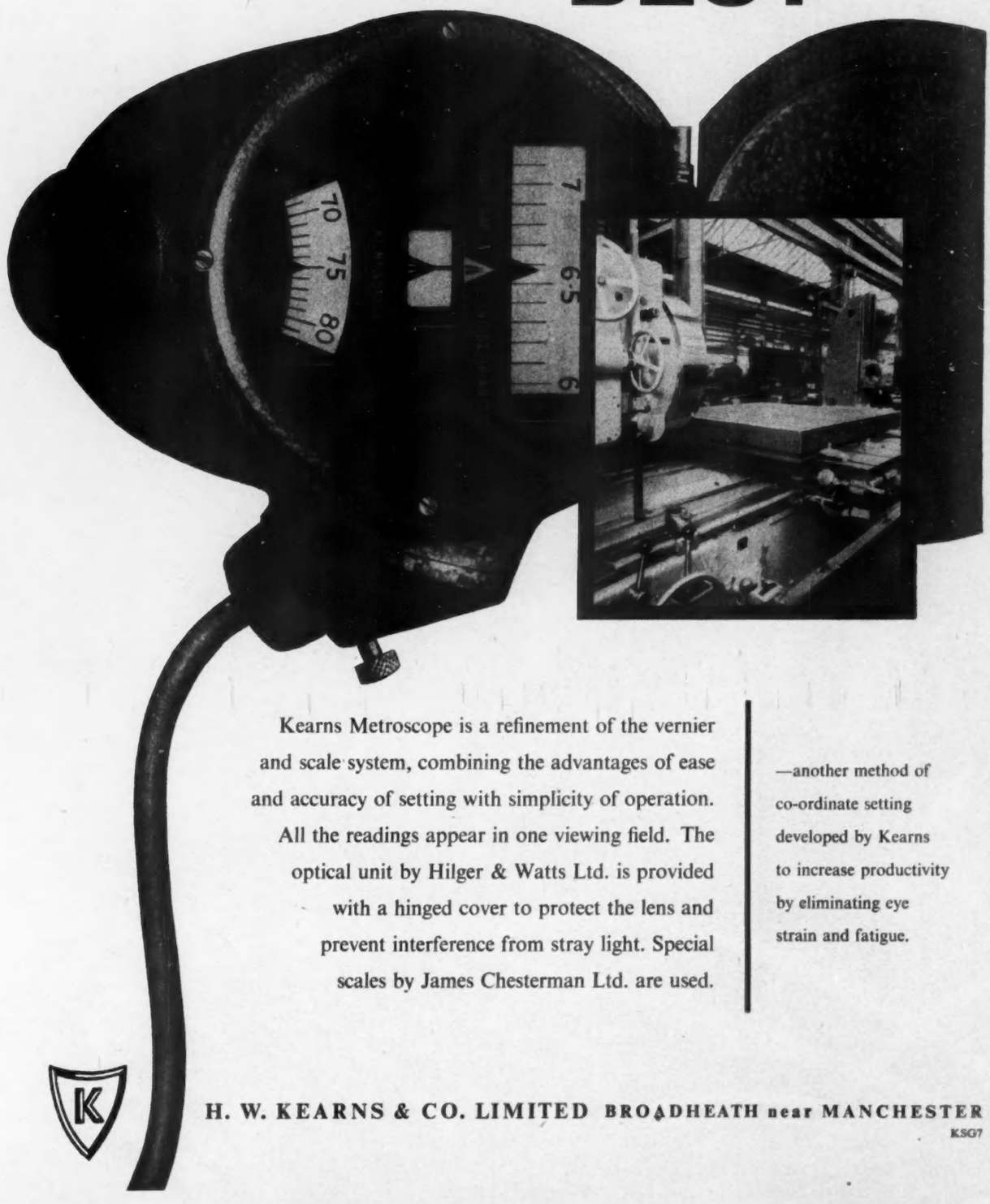

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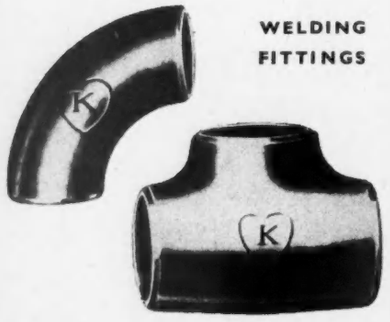

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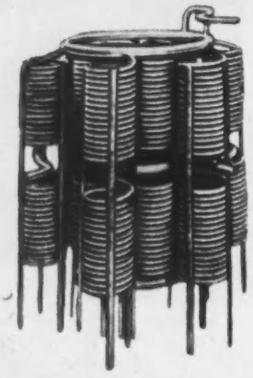

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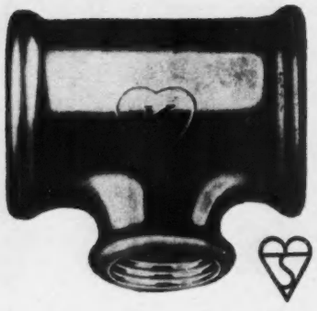

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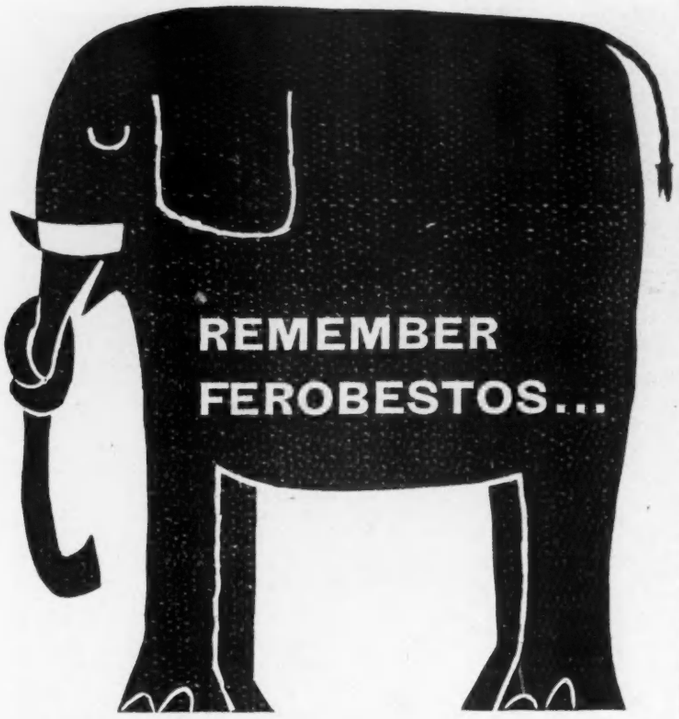

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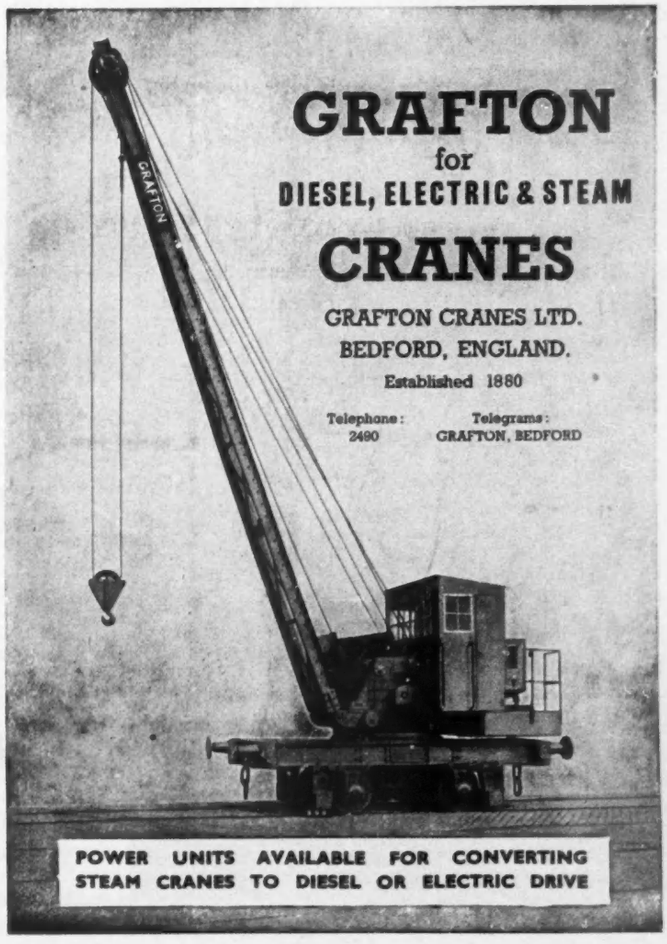

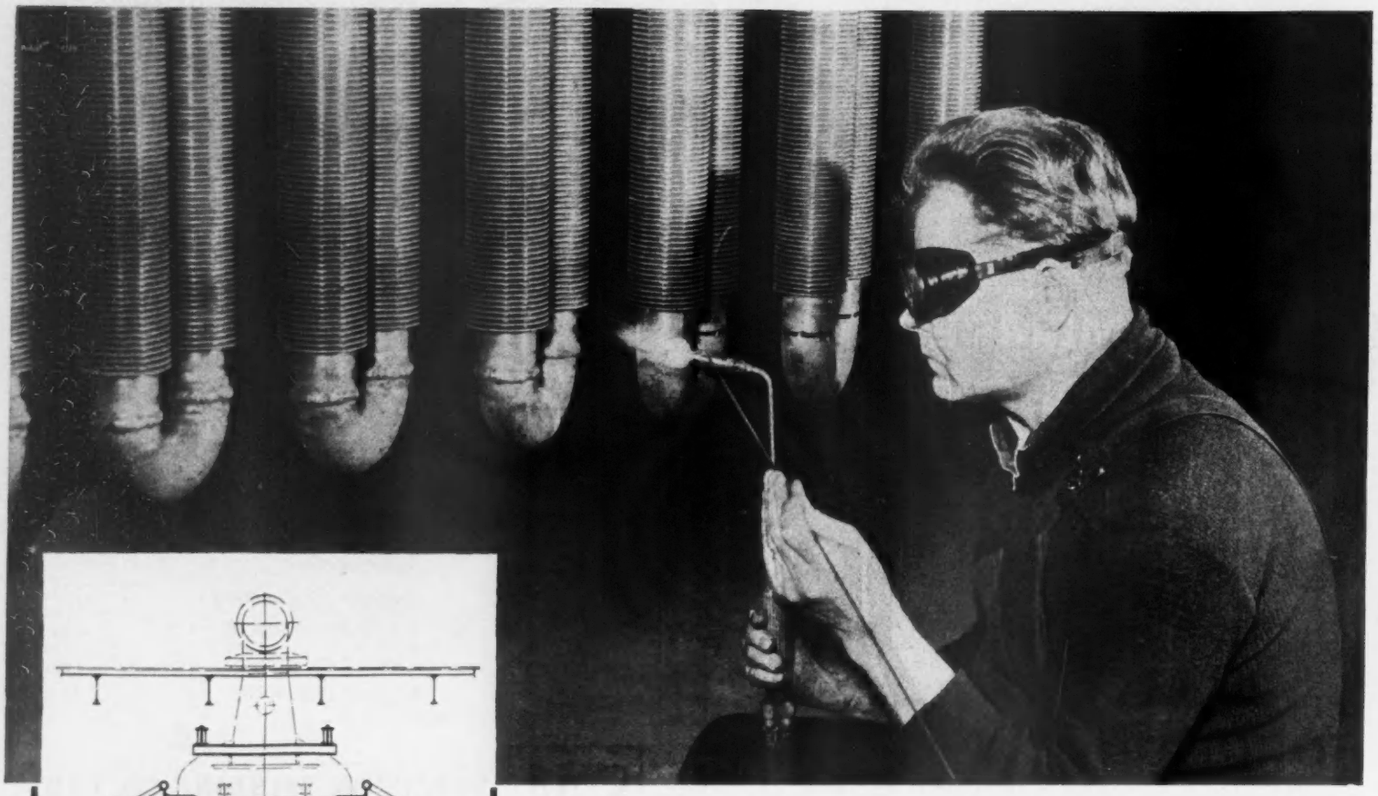

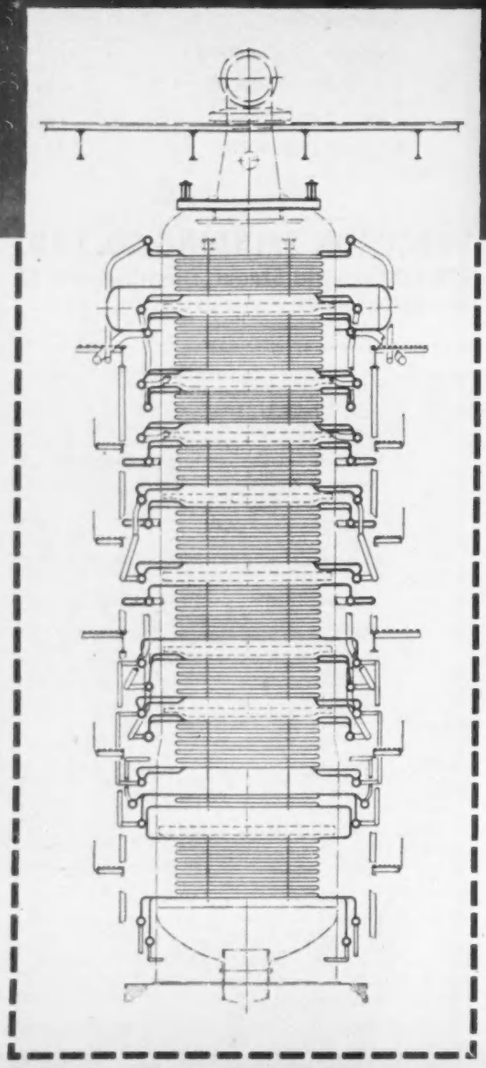

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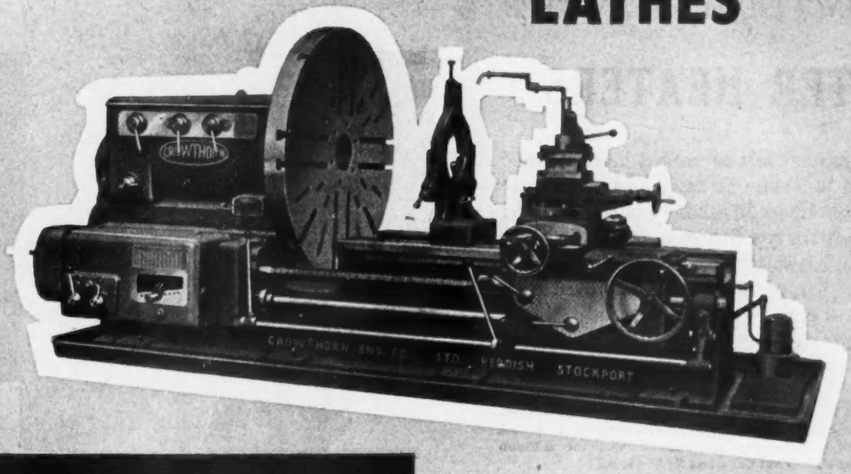

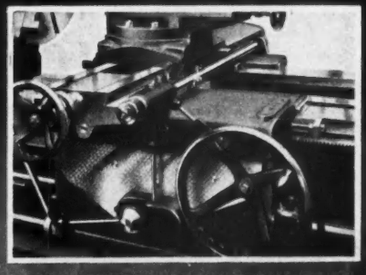

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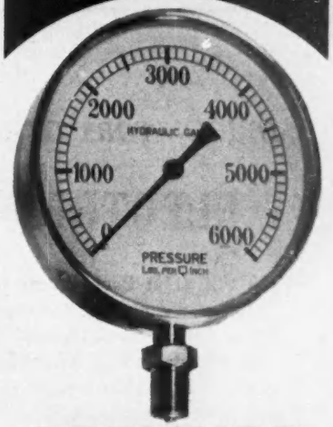

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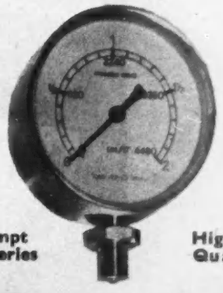

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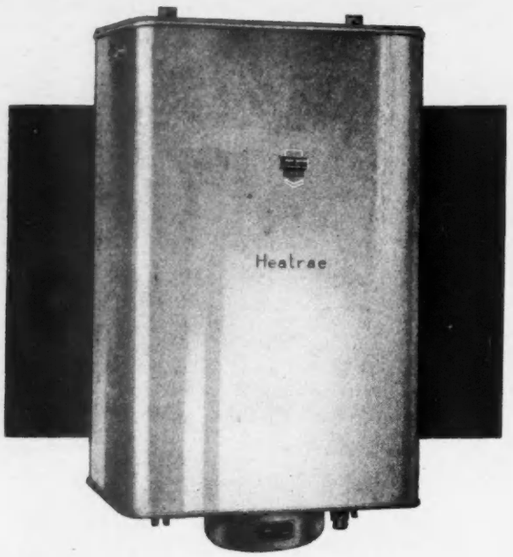

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Material: Nuts 28 & 40 ton steel (Code A & P)
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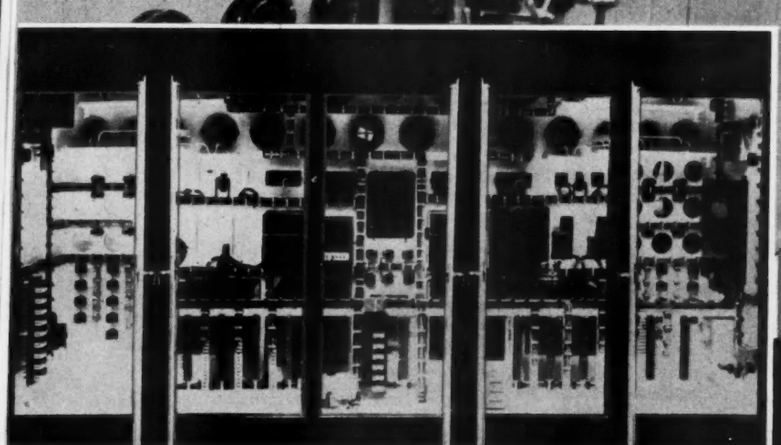
Instrumentation FOR TURBO-GENERATING PLANT

✳ Power in the making



A control panel for a PARSONS hydrogen cooled generator.

The rear of a PARSONS turbine gauge board.

✳ Instrumentation work by PARSONS grows in quantity and importance as turbo-generator sizes, steam pressures and temperatures increase. The control of power station generating plant is vital and the instrumentation must be robust and reliable.

TURBO-GENERATORS TRANSFORMERS CONDENSING PLANT

PARSONS

C. A. PARSONS & CO. LTD.

HEATON WORKS · NEWCASTLE UPON TYNE 6

Angle Bay to Llandarcy

60 miles of SOUTH DURHAM STEEL PIPES

Photograph shows the Llandarcy Refinery with pipes, which will be buried at a minimum of 2' 6" under ground, lying alongside the trench in readiness for welding.

– in Britain's latest and longest crude oil pipeline

From The British Petroleum Company's new deep-water tanker terminal at Angle Bay on the south shore of Milford Haven, an 18-inch diameter pipe line will carry crude oil at a maximum pressure of 850 lbs. per square inch to the Company's vast refinery at Llandarcy, sixty miles away.

For this contract, South Durham have been privileged to supply the steel pipes throughout the entire length of the line plus an additional five miles of 26-inch diameter pipe for supplementary services.

Another example of the way in which South Durham high-quality line pipe is serving the petroleum industry in every quarter of the globe.

South Durham

SOUTH DURHAM STEEL AND IRON COMPANY LIMITED

Central Sales Office: **CARGO FLEET IRON WORKS, Middlesbrough, Yorks**

Telephone: Middlesbrough 46311 (13 *lines*)

Incidentally, South Durham have also supplied over 5,000 tons of their "Rendhex" Steel Hexagon Foundation Columns in special lengths for the deep-water foundations to the tanker jetty at Angle Bay.

Have you a thickness measuring problem ?

Compact and easy to use,
the Elcometer provides a simple economic method of measurement from one side without damage to surfaces.
It gives split-second thickness readings of all non-magnetic coatings on ferrous bases with an accuracy of ±5% ± ·0001 in.
Non-ferrous foils, sheetings, etc., can also be measured if laid on a ferrous base.
The Elcometer, now in a newly designed unbreakable case, is available in a wide range of models, including versions for gauging Ferrite percentage content of stainless steels and graphitic corrosion penetration in cast iron.

THE ELCOMETER

THICKNESS GAUGE

MEASURES :—
Coats of Paint.
Vitreous Enamel.
Tobacco Leaves.
Plastic Coating or Sheets.
Fibreglass Hulls and Bodies.
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For further information, send coupon for free booklet. You are also invited to seek advice from our technical experts.

To East Lancashire Chemical Co., Ltd., Fairfield, 1, Manchester.

Please send me copies of booklets "The Elcometer Thickness Gauge," and "The Elcotector."

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For the attention of.....

Have you heard about the new **Elcotector,** *which :—*

Measures—
Metallic coatings on metallic bases.
Non-metallic coatings on metallic bases.
Metallic coatings on non-metallic bases.

Compares—
Hardness of steel.
Grades of alloys.
Grades of steel.

Locates—
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Equipment able to resist low Temperatures

is required to an ever increasing extent for:

Air liquefying plants, Fractional distillation of hydrocarbons

Liquefied petroleum gas transport

Phoenix-Rheinrohr highly experienced in the smelting of specialty steels and the creation of new materials offers suitable steels for these applications:

- low-alloy steels ductile at sub-zero temperatures
- 3 and 5% nickel steels
- austenitic stainless steels

For equipment exposed to very low temperatures we developed our new

AUSTENITIC MANGANESE-CHROMIUM STEEL

Even shortly after its inclusion in our production program this steel is being used to a fairly great extent for the construction of low-temperature plants owing to its good ductility at sub-sero temperatures and its favourable price.

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open shelves can be
TOMORROW'S
fitted units

Here is a storage system which is so flexible that it can always be completely up-to-date.

From the carefully designed range of components, it is an easy matter to plan and erect an installation which will not only satisfy immediate storage needs but which can also be rapidly adapted to meet new requirements. Large articles or small, many or few, can be segregated as desired, and sections may be enlarged, reduced or subdivided at any time to conform to a changing pattern of purchases, production and consumption.

Components are made from best quality mild steel sheet and rolled steel sections, and are available in a range of standard sizes. Stove enamelled Olive Green or Scarborough Grey.

A typical three-bay assembly of trays, bins and shelves. The reverse side incorporates bins, cupboards and a ledge top. Bays may be varied as required, and joined to form a continuous run.

Full details of components and a selection of specimen assemblies are shown in List 1015. Please send for a copy. Mobile Type Shelving also available. Details on request.

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ANGLE POST TYPE
(Based on B.S.826 : 1955)

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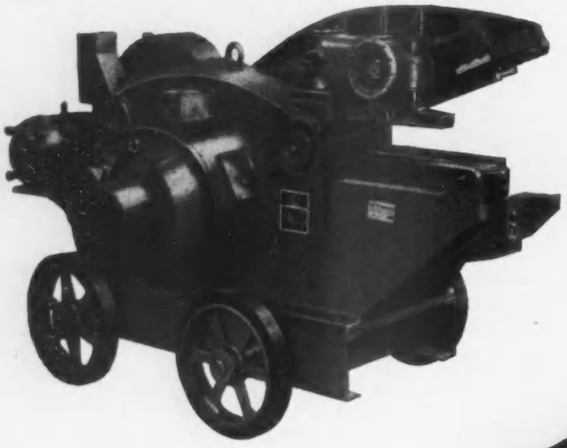
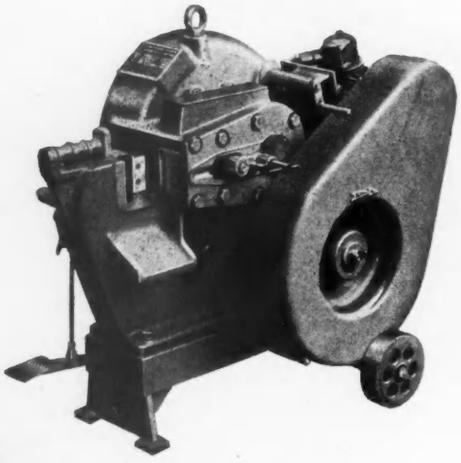
Shears available

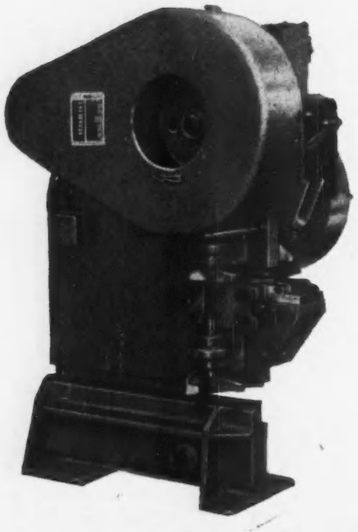
From Stock or Early Delivery





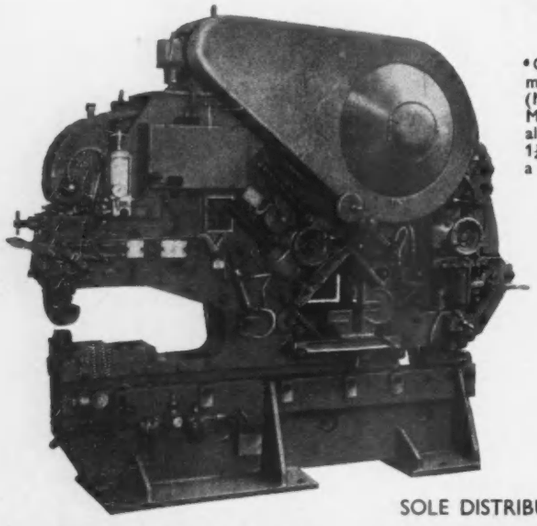
ALLIGATOR SHEARS; four sizes, capacities 1 $\frac{5}{8}$in. to 4$\frac{1}{2}$in. M.S. rounds, etc., gears running in oil; clutch control; adjustable hold down; electric or diesel engine drive

UNIVERSAL PUNCHING, SHEARING, CROPPING and NOTTING MACHINES; five sizes, capacities shearing $\frac{3}{8}$in. to 1in. M.S. plates, etc.; five operations contained in one power driven unit. Alternative models; without punching motion and single purpose punching machine.

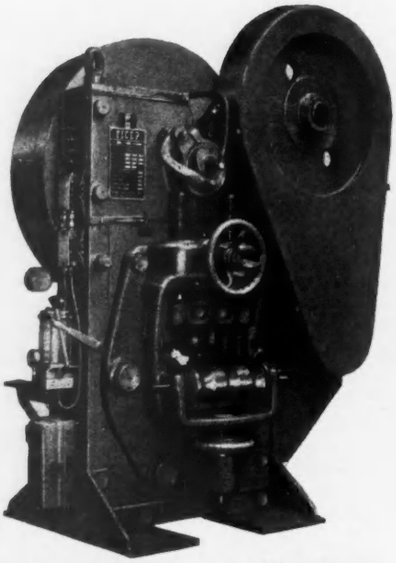


PORTABLE BAR SHEARS; five sizes, capacities 1in. to 2$\frac{3}{4}$in. M.S. rounds; gears running in oil; clutch control.

BILLET and BAR SHEARS; nine sizes, capacities from 1in. to 8in. dia. M.S. bars; power feed tables, fully automatic operation can also be supplied.



•COLTS' SHEARING MACHINE Basic machine (Type 1) has shearing capacities (M.S. flats) up to 3$\frac{1}{2}$in. × $\frac{1}{2}$in., and slitting M.S. plates up to $\frac{3}{8}$in. thick. Type 2 has also bar cropping facilities handling up to 1$\frac{1}{2}$in. dia., 1$\frac{1}{8}$in. square. Type 3 incorporates a notching unit.



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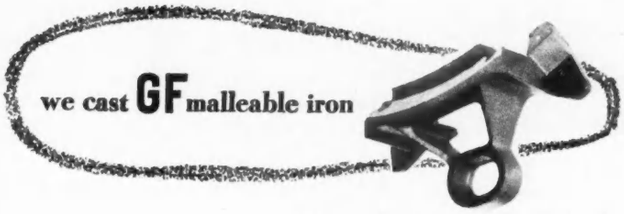

The applications of **GF** *Malleable Iron are virtually unlimited. Please consult us when you next require castings.*

GF MALLEABLE CASTINGS

BRITANNIA IRON & STEEL WORKS LIMITED
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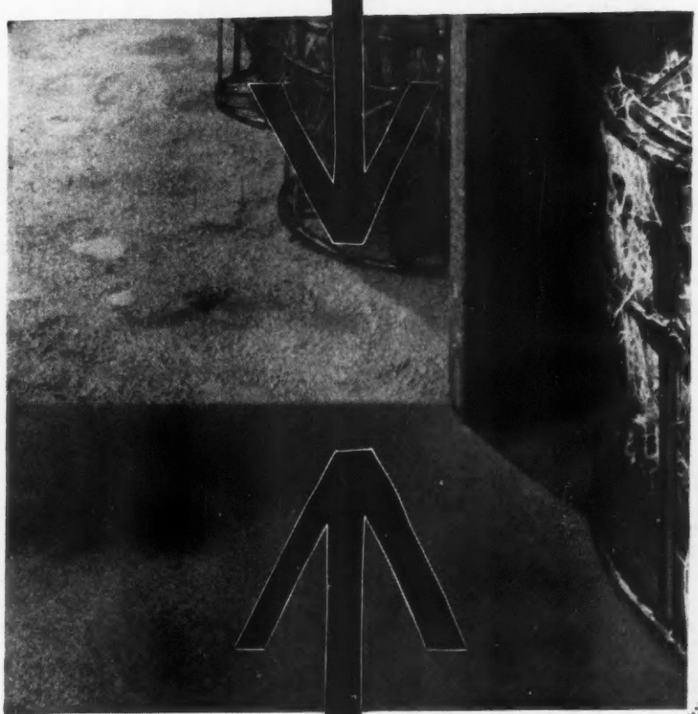

Concreted Factory Floor after 3 months wear showing untreated and Ceradek treated surfaces.

Solve your flooring problems with epoxy-resin-based Ceradek, the screeded surfacing which is resistant to a wide range of chemicals. Dry or wet, a safe non-slip surface. No dust hazards and laid in continuous, unbroken surfaces with great resilience and high impact strength. Light in weight. Available in four colours. Withstands heavy traffic after laying, and bonds tenaciously to various surfaces (old or new concrete, etc.)

Many times stronger than concrete, Ceradek is the complete, protective surfacing which offers large scale economies and hard-wearing, long life. It it suitable for an almost unlimited number of industrial applications. Our technical staff will gladly advise you on all aspects of Ceradek installation. Please write for further details, specific recommendations and quotations as required.

WITH Ceradek Epoxy SCREEDED FLOORING

Laid only by : TECHNICAL APPLICATIONS LTD.
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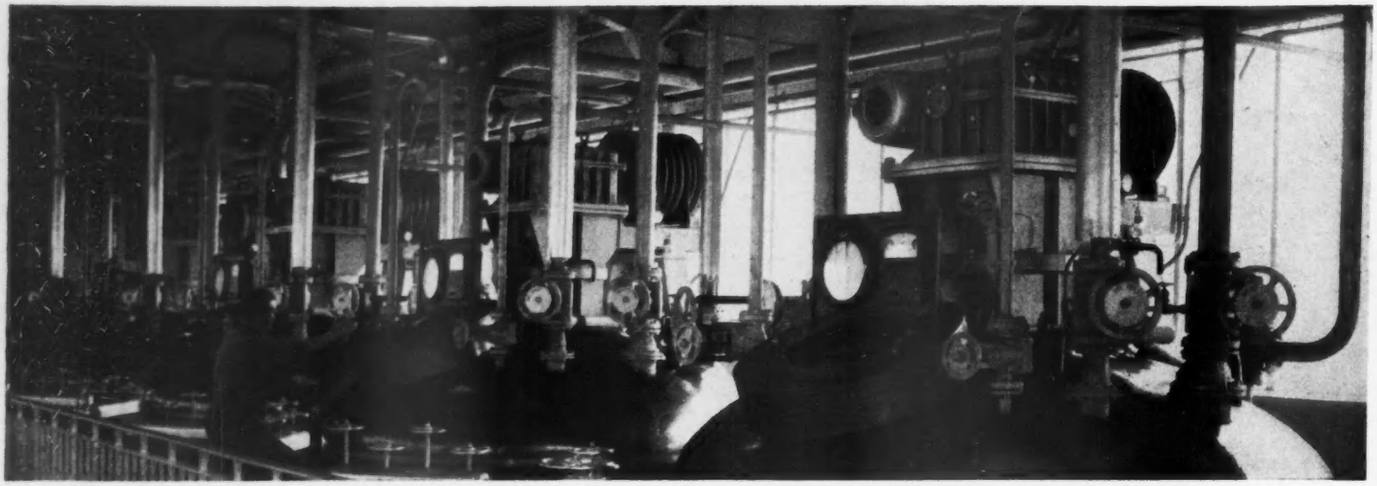
WISEMAN GEARS ARE UBIQUITOUS

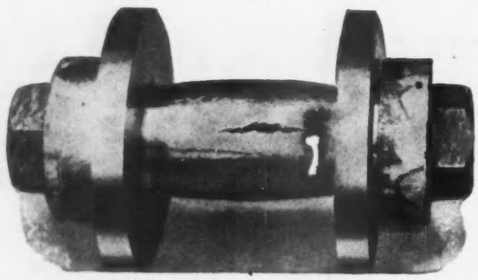


Wiseman offer a range of gears so wide that it is possible to select the correct design for almost any application. In the world of gears Wiseman have long been renowned for high efficiency and reliability. Yet another difficult application successfully encountered is illustrated here. A group of hardening vessel agitators are driven through Wiseman T.E. Vertical Type Worm Reduction Gear Units at the Stork Margarine Work, Purfleet. Consult Wiseman with your next gear problem.

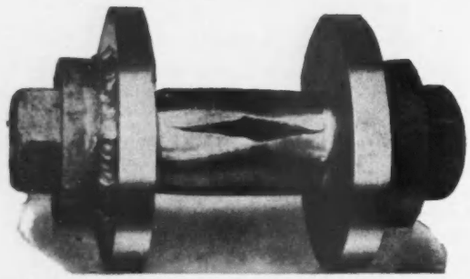
ALFRED WISEMAN & CO LTD

Glover Street, Birmingham 9. Telephone: VICtoria 2216-7 *London Office:* Carlisle House, 8 Southampton Row W.C.1. Telephone: HOLborn 7127

Remarkable performance of Aluminium Bronze



Gun-metal 0·25 in. *thick—burst at* 4480. *lbs. per sq. in.*



Aluminium-bronze 0·10 in. *thick—burst at* 4816 *lbs. per sq. in.*

0·10 IN. SHELL WITHSTANDS OVER 2 TONS PER SQ. IN.!

Recently we tested to destruction two similar hollow castings—one in gun-metal, the other in aluminium-bronze. The gun-metal had a wall thickness of **0·25 in.** and withstood pressures up to 4480 lbs. p.s.i.—a very good performance. The casting in aluminium-bronze burst at a slightly higher pressure (4816 lbs. p.s.i.) **but its wall thickness was only 0·10 in.** Surely an impressive demonstration of the weight/strength characteristics of this alloy.

We were one of the first foundries to cast in aluminium-bronze and to-day we supply castings in this alloy to customers all over the world.

CASTINGS FROM A FEW OUNCES TO 10 TONS . . .

in all non-ferrous alloys. Precision machining. Specialists in aluminium-bronze, centrifugal-cast wheel blanks, shell moulded castings and chill-cast rods and tubes, continuous cast phosphor-bronze bars up to 12 *foot lengths.*

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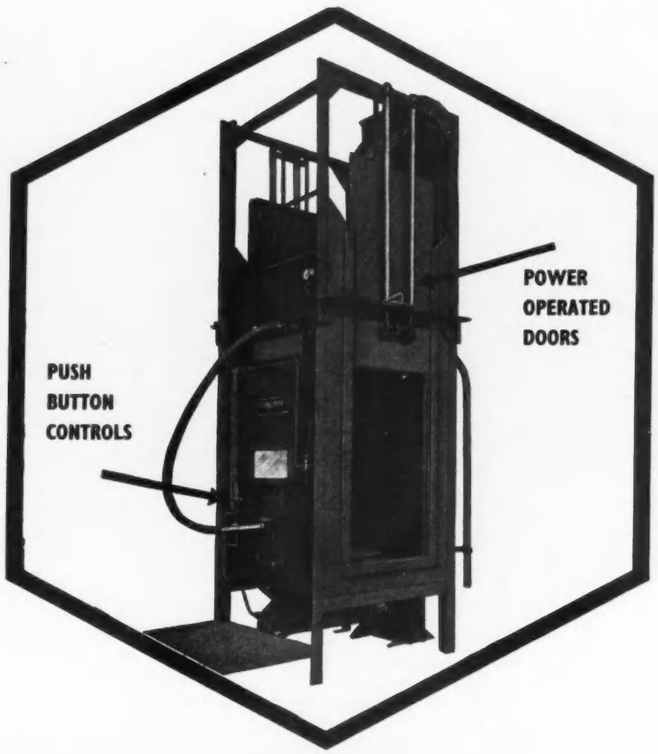

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ST. GEORGES
SHOT BLAST
PLANTS
INSTALLED IN THE NEW
FORD
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Fords have chosen the Best

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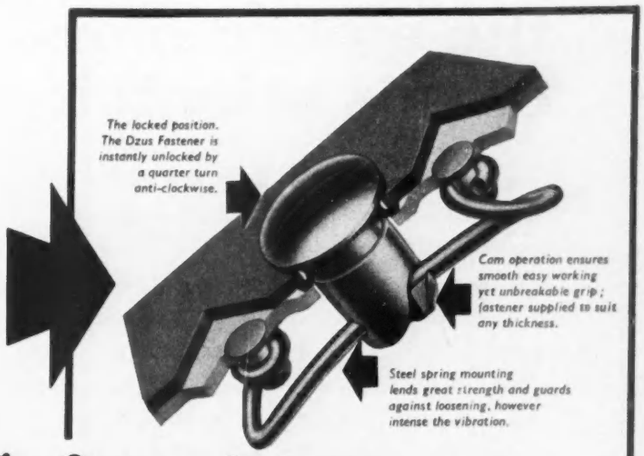
The locked position. The Dzus Fastener is instantly unlocked by a quarter turn anti-clockwise.
Cam operation ensures smooth easy working yet unbreakable grip; fastener supplied to suit any thickness.
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Dzus can easily be fitted in solid or laminated materials, regardless of thickness. Dzus have tremendous holding power. Quick in action! Vibration proof! They are indispensable for hinged or removable parts which need frequent inspection, cleaning or adjustment. THE FASTEST FASTENER with the 101 uses for Inspection Hatches and Panels, Engine Covers, Machinery Guards, Fascia Panels, Radiator Grilles and with a variety of uses in the Electronic, Motor Vehicle and Shipbuilding Industries.

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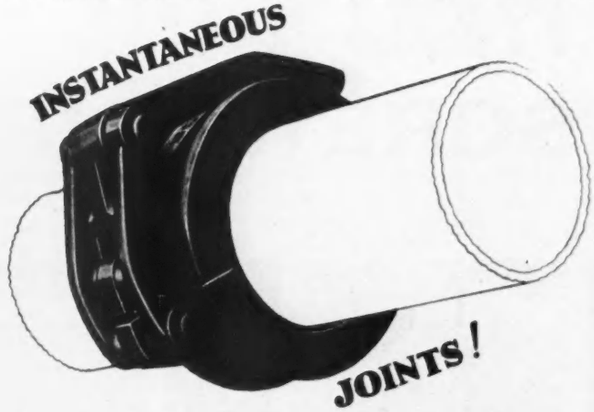
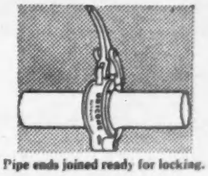


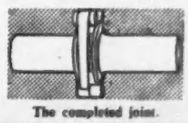
A perfect seal in a matter of seconds

For temporary pipelines 'Unicone' instantaneous joints are recommended. Comprising two parts only, they fasten with a "snap" ensuring a perfect seal in a matter of seconds.

For permanent or semi-permanent pipelines 'Unicone' bolted type joints are usually employed and can be assembled far more quickly than any flexible joint giving positive anchorage.

Rubber gasket in position and joint ready to pull over.


Pipe ends joined ready for locking.


The completed joint.

'UNICONE' REG'D.

Flexible Joints for Pipelines

leakproof. safe. reliable

THE UNICONE CO. LTD.
RUTHERGLEN, GLASGOW, SCOTLAND

V. G.

the embodiment of this scientific age

Forward-looking engineers are embodying Heli-Coil Screw Thread Inserts in their designs because competition demands that they use only today's most advanced and successful techniques.

The Heli-Coil method of screw thread engineering can improve products in almost an infinity of ways . . . and at the same time make dramatic cuts in time and labour costs. It is ideal for automation, the operation is simplicity itself, just drill, tap and install.

The Heli-Coil Insert provides a conventional thread with higher loading strengths and greater resistance to wear and stresses – it literally *armours* the thread.

The assembly obtained is anti-vibration because the Heli-Coil Insert allows pre-stressing. Weight and space are saved and the serviceability and appearance of the product enhanced.

The importance of Heli-Coil Inserts to the modern designer is an irrefutable fact. Why not have all the information in front of you – data is freely available. Ask for Sales Leaflet APL48/E5.

HELI-COIL*

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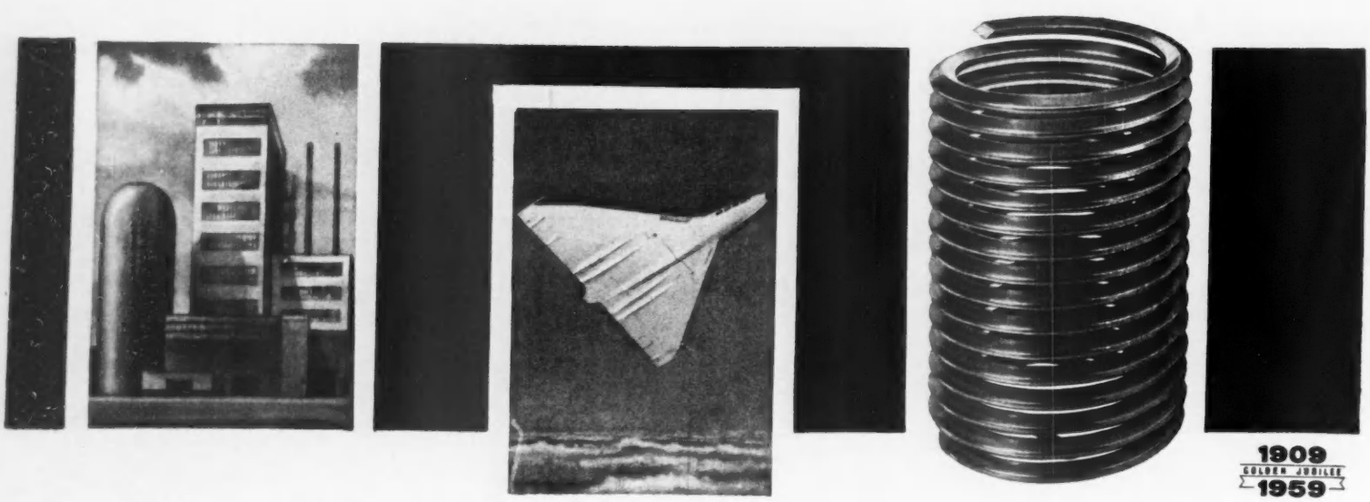

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Your newest design . . . is it quite up to date?

*HELI-COIL is a registered trade mark

Write for more data on HELI-COIL inserts to **ARMSTRONG PATENTS CO., LTD., EASTGATE, BEVERLEY, YORKSHIRE**

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COAL

MECHANICAL STOKERS

AND THE

CLEAN AIR ACT (1956)

MINISTER'S ORDER

what it means to you

IF YOUR PLANT IS SITUATED IN A SMOKE CONTROL AREA AND . . .

. . . *you are planning to instal a boiler or furnace* you can now instal mechanical coal-burning equipment – the most efficient method of producing the maximum heat from the minimum of solid fuel. Your plant must, of course, be properly installed, maintained and operated. *Bituminous coal may be used as fuel.*

. . . *you are using bituminous coal* you may continue to do so if your mechanical stoker was installed in 1957 or later and you maintain and operate it properly. *No application for permission from any authority is necessary.*

If your mechanical stoker was installed before 1957 and you want to continue using bituminous coal, you can apply for exemption to your Local Authority. The National Coal Board will make sure that you can get the right coal.

Remember that the cost of a modern mechanical stoker is about £1,200. For the supply of hot water heating only, the cost is as low as £300–£400.

The operating costs using coal with a mechanical stoker compare very favourably with *all other forms of heat.*

IF YOUR PLANT IS OUTSIDE A SMOKE CONTROL AREA YOU ARE NOT IMMEDIATELY AFFECTED BY THE NEW ORDER BUT . . .

. . . *If you are an industrialist* remember that your Local Authority may, *at any time*, give notice that it intends to create a Smoke Control Area where *your* factory is sited. That is why it is sound policy to plan *now* to instal a mechanical stoker – the most economical method of producing heat from bituminous coal. And the National Coal Board will make sure that you can get the right coal.

If you work in the coal industry

Remember that this Order will help to create an increasing, long-term demand for bituminous coal. That, in turn, means more work for everyone connected with the production or distribution of coal.

If you are a 'man-in-the-street'

Remember that *everybody* is affected directly or indirectly by this Order. It will increase the use of coal – the home-produced fuel – under ideal conditions. The coal consumed need create as little 'smoke' as any other fuel. *Britain's smoke-free areas will stay smoke-free.*

THIS ANNOUNCEMENT IS ISSUED BY THE

NATIONAL COAL BOARD

If you have an industrial problem connected with COAL write (or 'phone) your nearest N.C.B. Regional Sales Manager

London & Southern:
Derbyshire House, St. Chad's Street, London, W.C.1
Terminus 8833

North Midlands:
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Mansfield 2500

Midlands:
Ednam House, Dudley, Worcs.
Dudley 55411

South Wales & West of England:
Ocean Buildings, Bute Docks, Cardiff
Cardiff 31011

Bristol:
Eagle House, St. Stephens Street, Bristol, 1
Bristol 26541

Swansea Branch:
Gloucester House, Gloucester Place, Swansea
Swansea 51541

North Western:
Kemsley House, 5/27, Withy Grove, Manchester, 4
Deansgate 7282

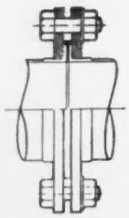
Yorkshire:
Ranmoor Hall, Belgrave Road, Sheffield, 10
Sheffield 32921

Leeds Branch:
27, Cavendish Road, Leeds
Leeds 31215

Northern:
Akenside House, The Side, Newcastle-upon-Tyne, 1
Newcastle 28577

Durham:
'B' Floor, Milburn House, Newcastle-upon-Tyne, 1
Newcastle 23541

Scotland:
6, Eglinton Crescent, Edinburgh, 12
Caledonian 1351



Here's an entirely new conception of piping —a comprehensive range of standard units, in four bore sizes (3", 4", 6" and 8") plus reducers that can be assembled, dismantled and re-assembled time and time again by comparatively unskilled labour. Swept bends and a unique system of gasket jointing eliminate all bacteria harbouring crevices and ensure an uninterrupted flow, free from blockages of any kind. Standard straights, bends, tees and reducers permit a wide variety of applications while further units can always be purchased for expansion or variation.

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STANDARD UNIT LIGHT-WALL STAINLESS STEEL PIPING

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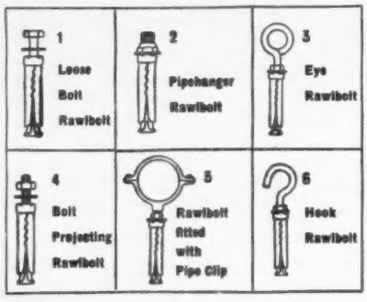

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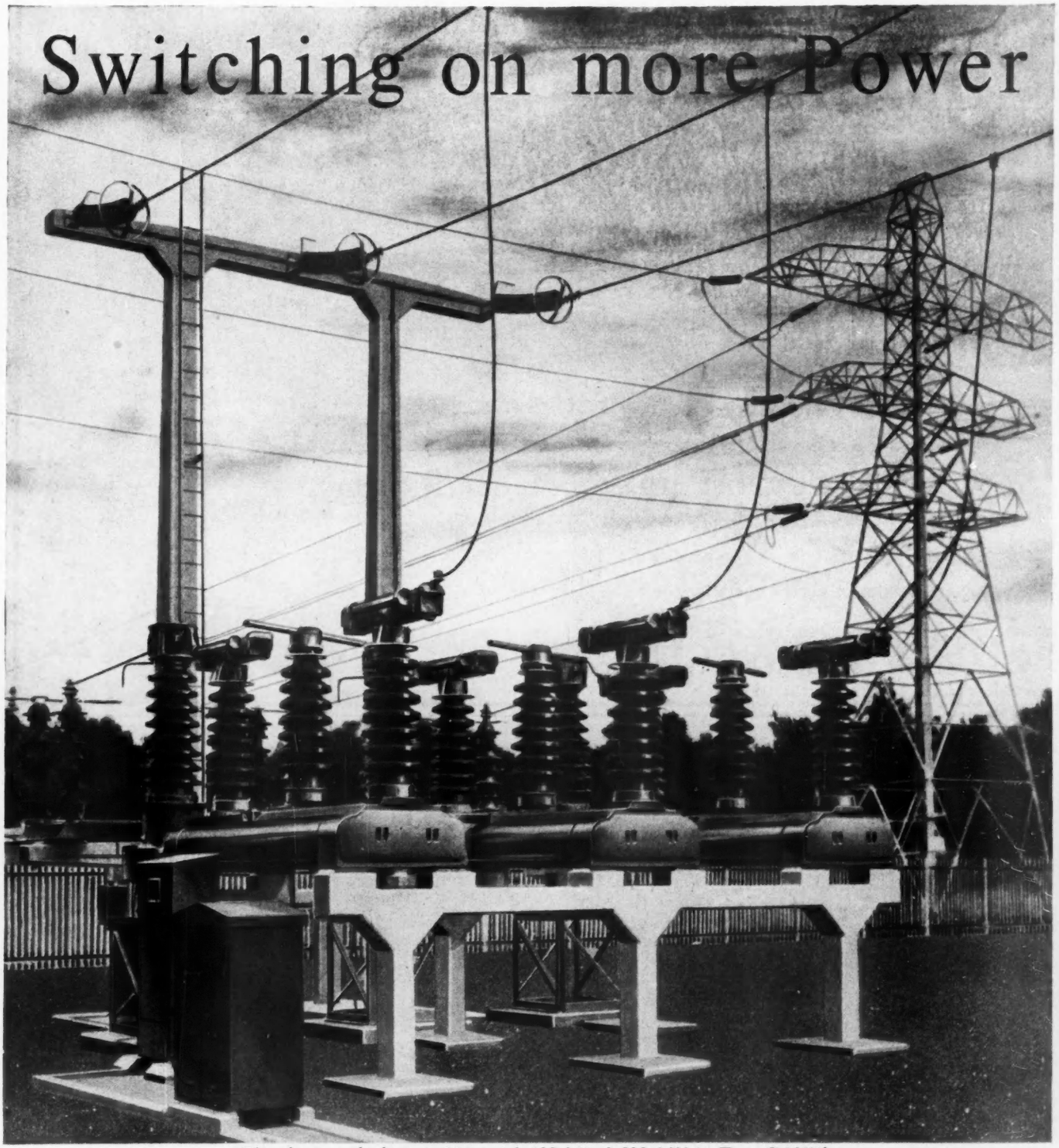

The photograph shows a Metrovick 132 kV., 3,500 MVA., Type GA6W4 Air-Blast Circuit Breaker installed in a British substation

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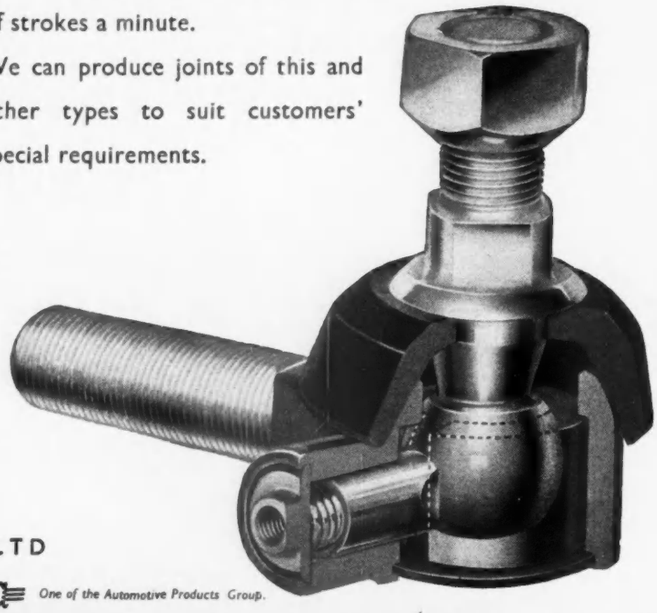

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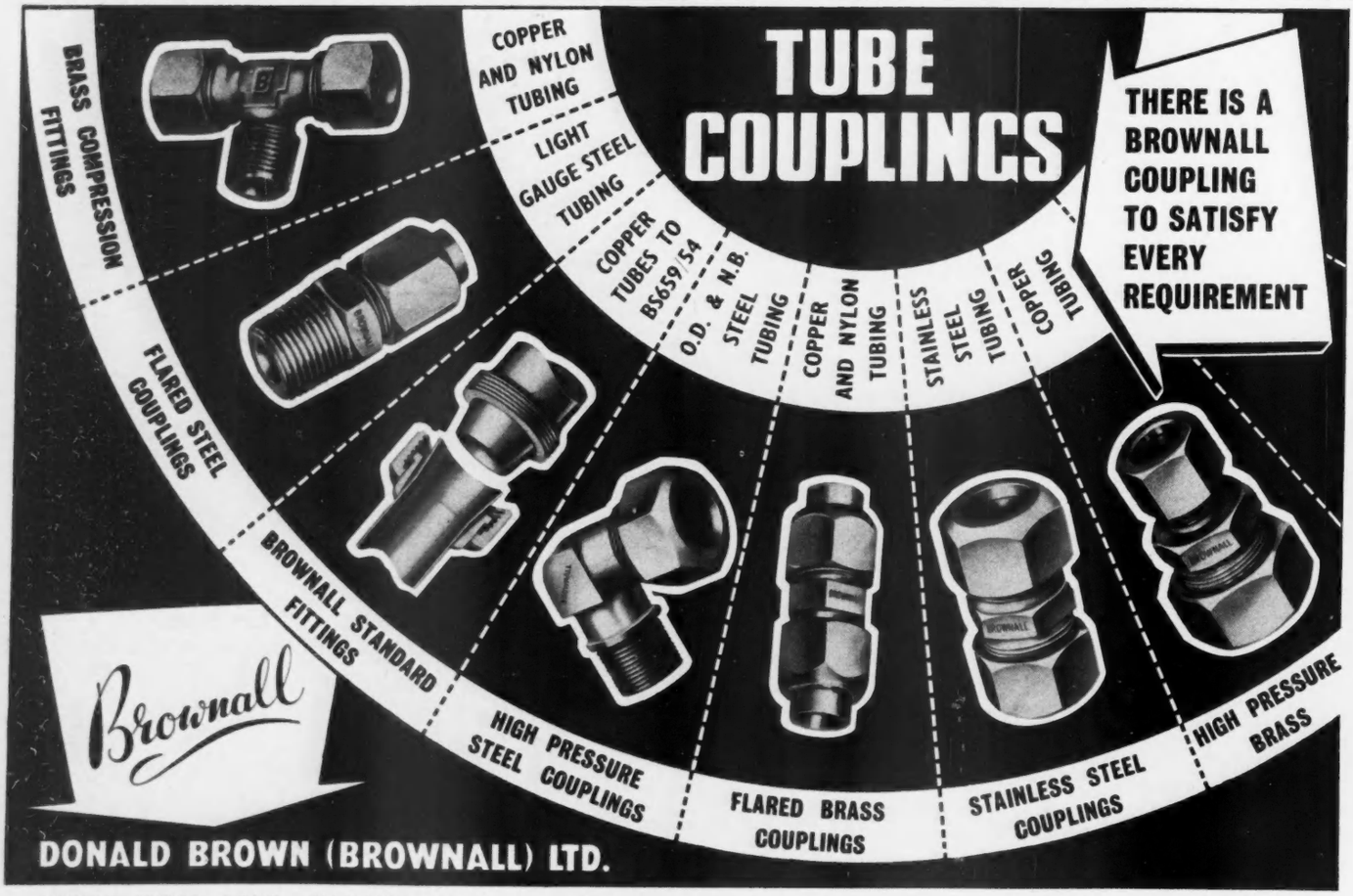

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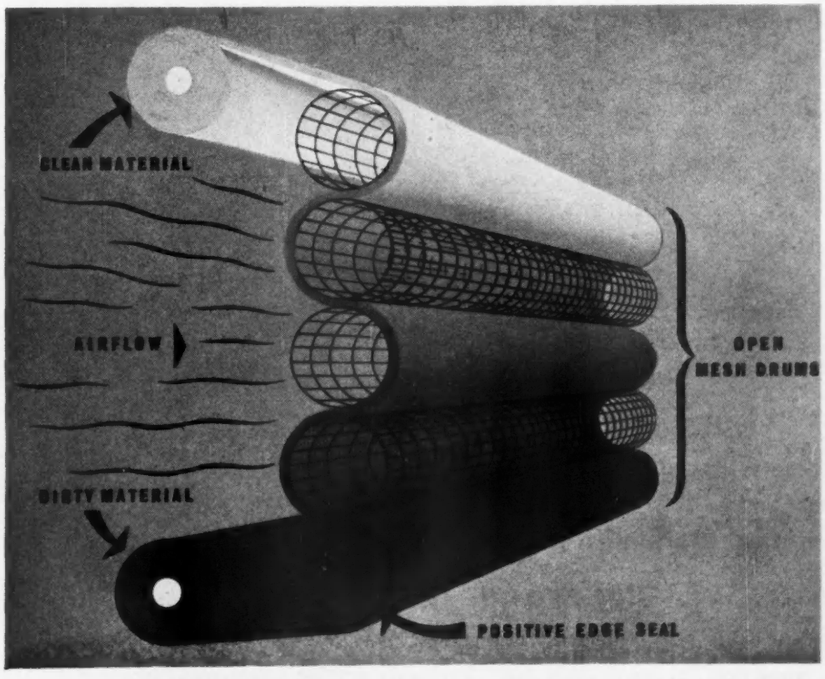

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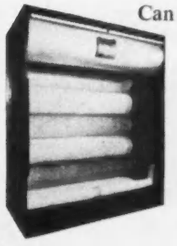

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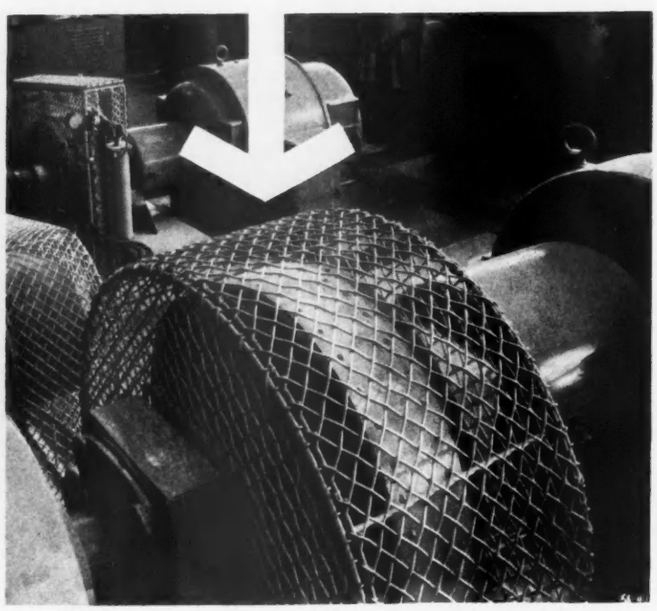

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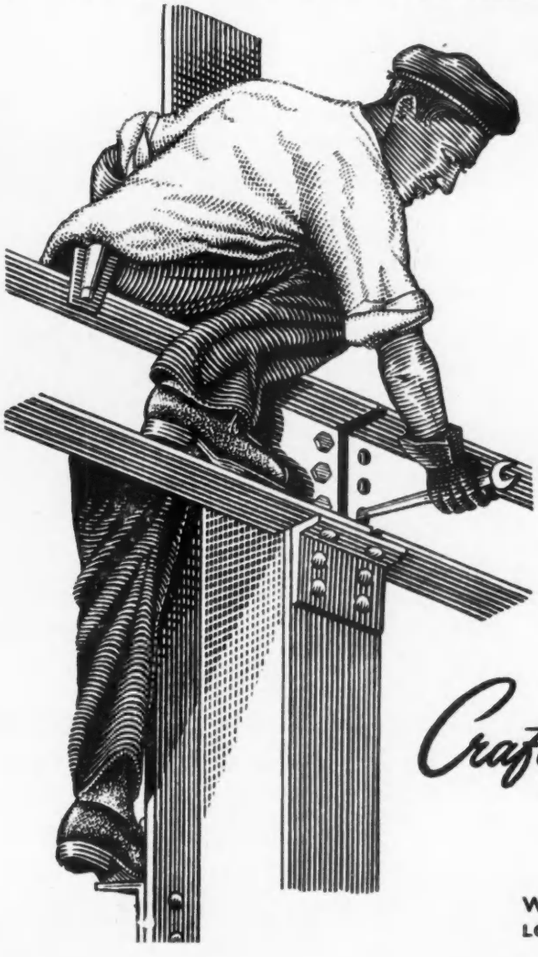

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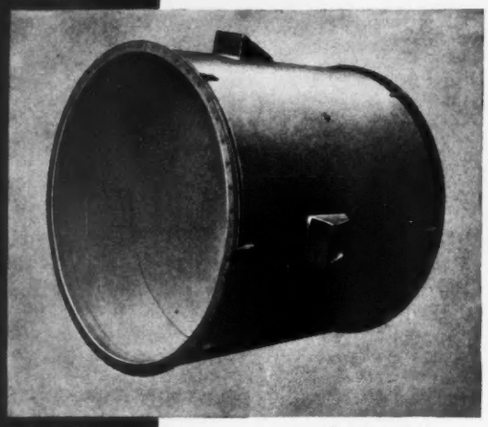

Stainless steel vessel with mild steel jacket

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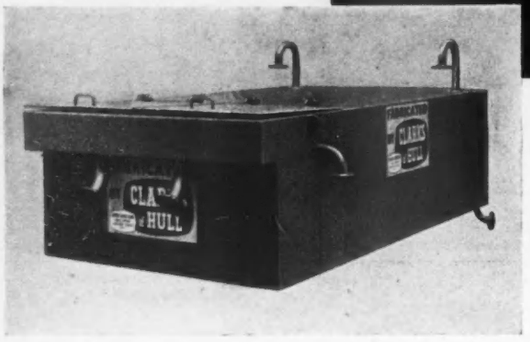

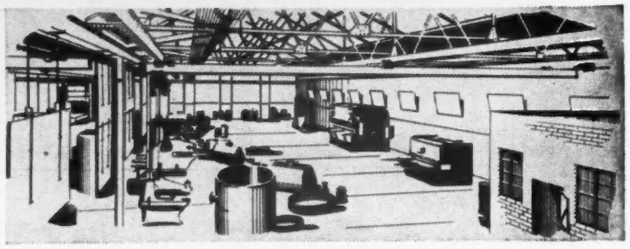

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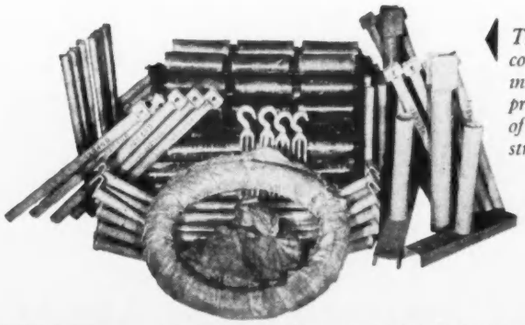
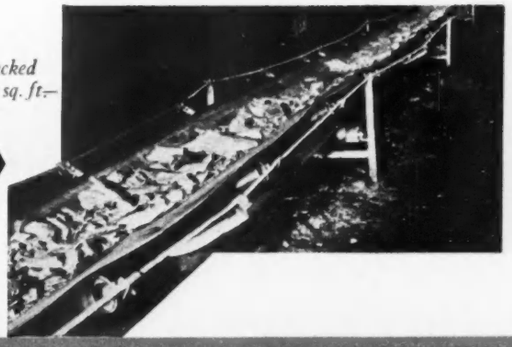


This group of components—stacked in an area of 28 sq. ft.—produce 200 ft. of this conveyor structure . . . .



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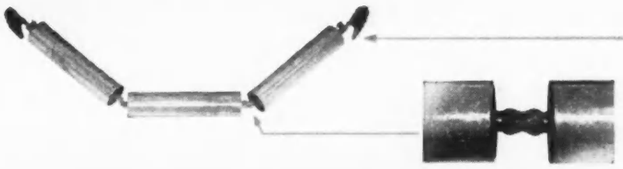
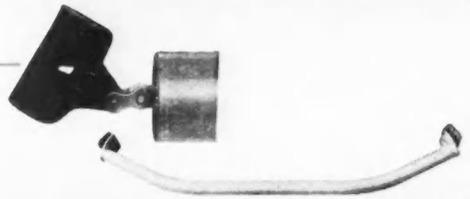


swivel links are fitted at each end of an idler shaft



stretchers are used at intervals between stands

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- *— increases belt life*
- *— reduces installation costs*
- *— increases capacity*
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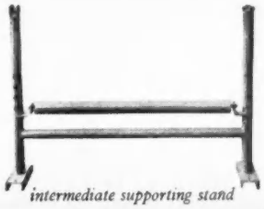
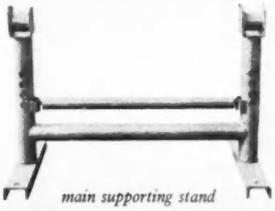
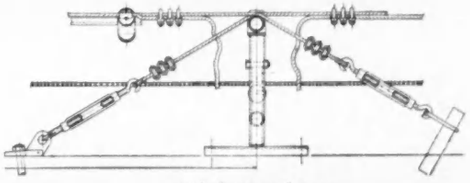
wire rope ⅞" dia. and 6 x 19 regular lay



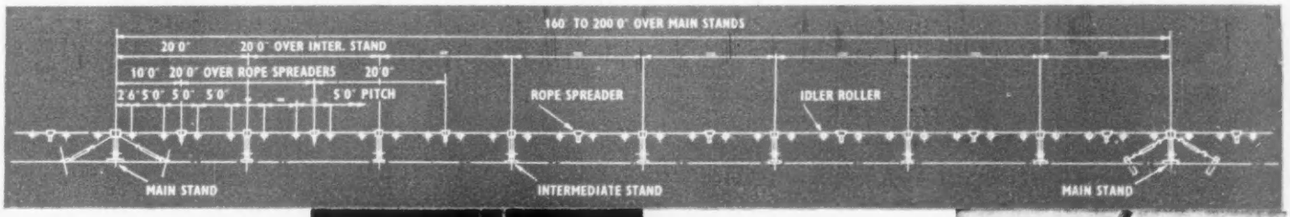
intermediate supporting stand



main supporting stand

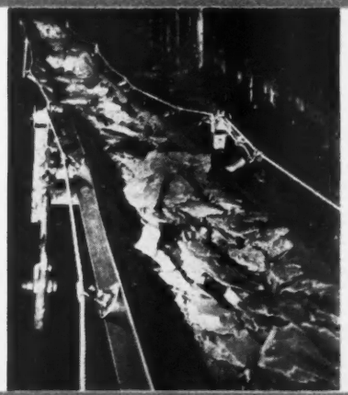


typical rope anchorages



Installation, extension and contraction of Distington-Goodman Rope Belt Conveyor Structure is relatively quick and easy.

(Right) Detail of a main stand and anchor point. These can be spaced up to 400' apart according to requirements.



A 36" rope belt conveyor installed at a quarry, carrying 500 tons of gravel per hour. By securing the rope to terminal pulleys it has proved practicable to move this conveyor bodily sideways by the dragline shown in the illustration.

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WORKINGTON CUMBERLAND ENGLAND

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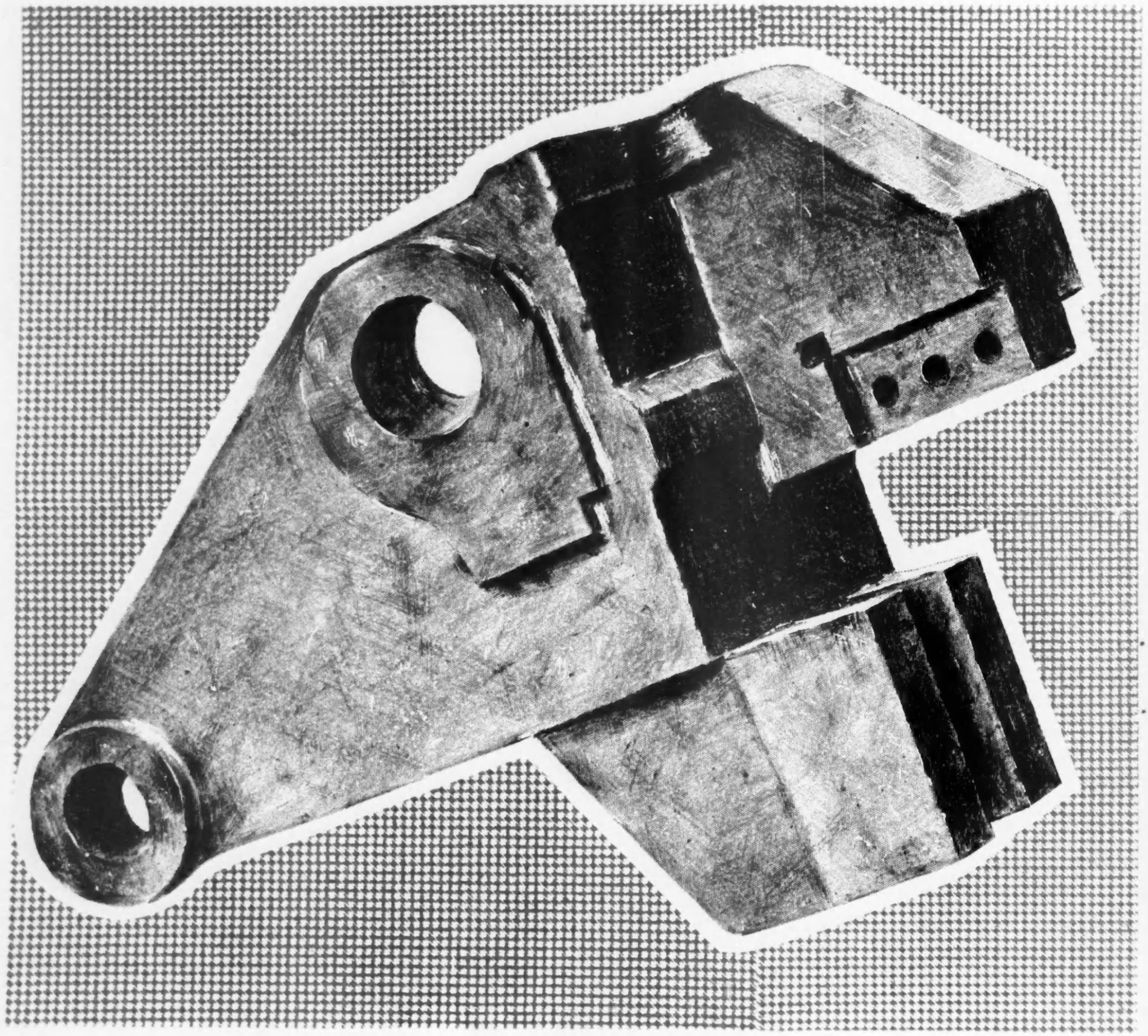

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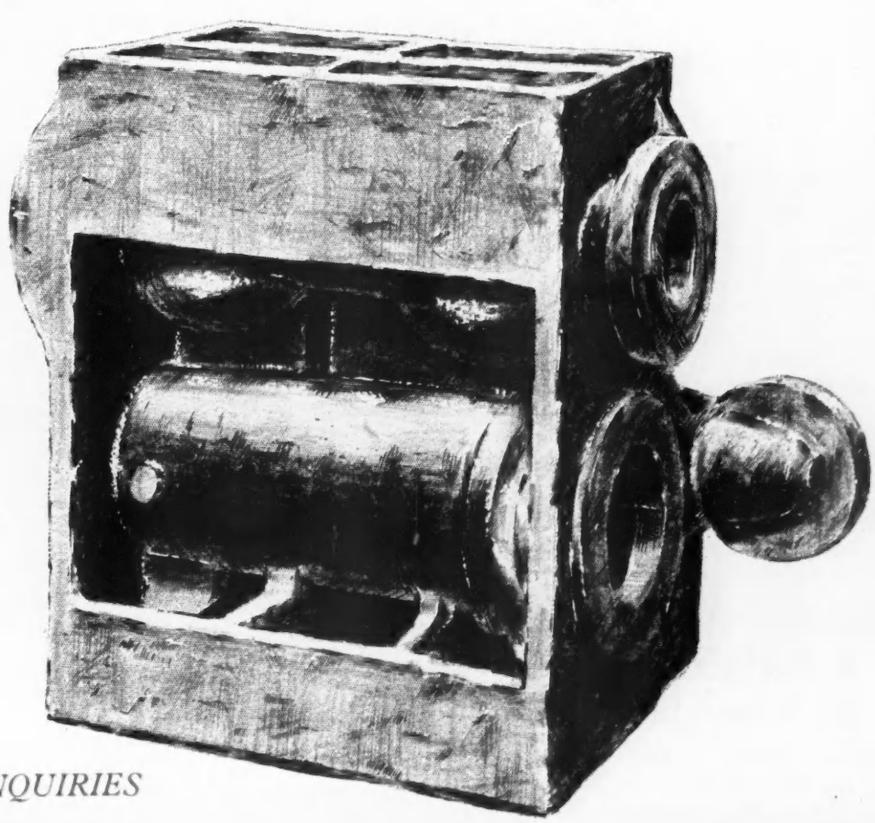

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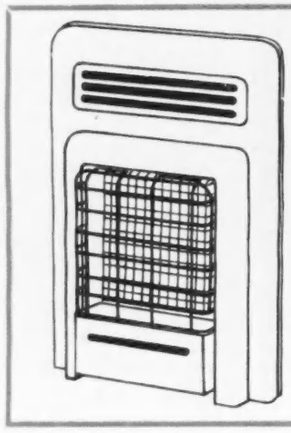

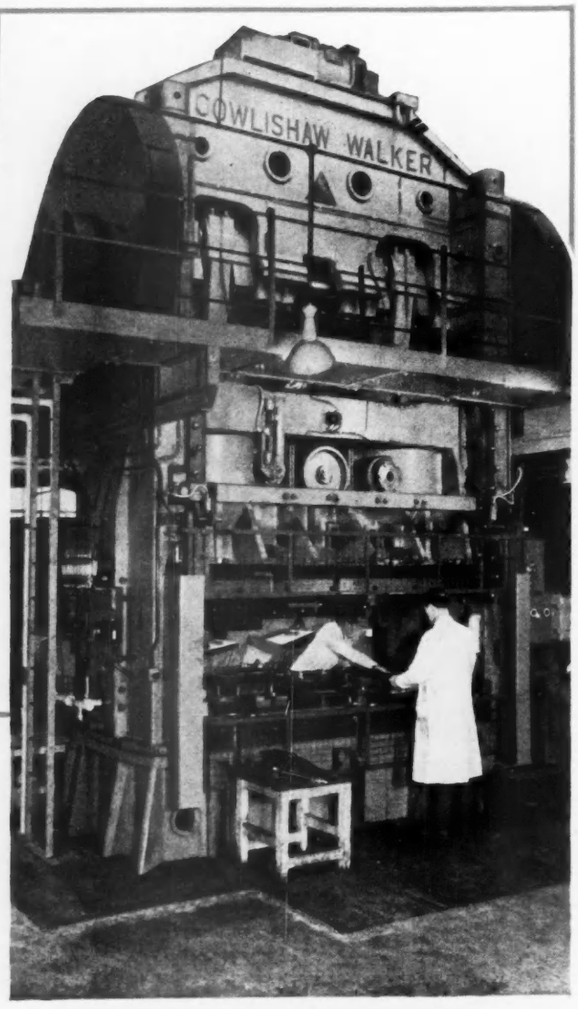

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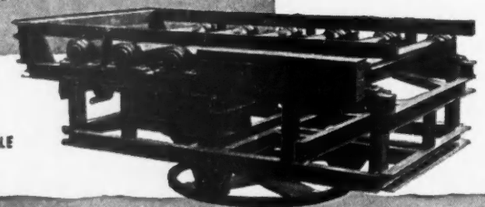

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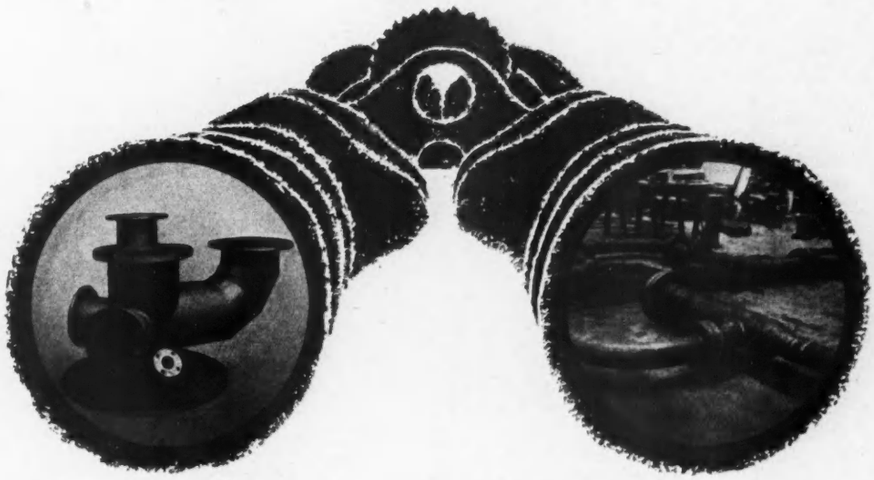

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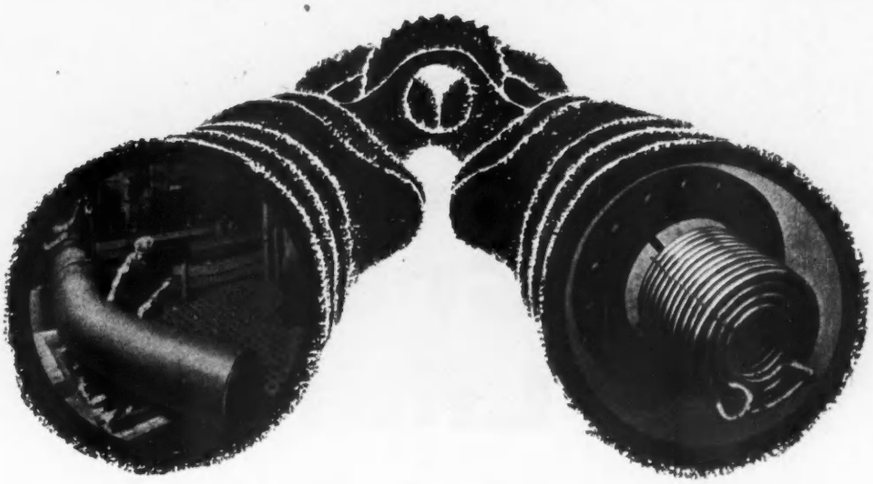

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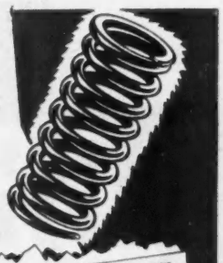

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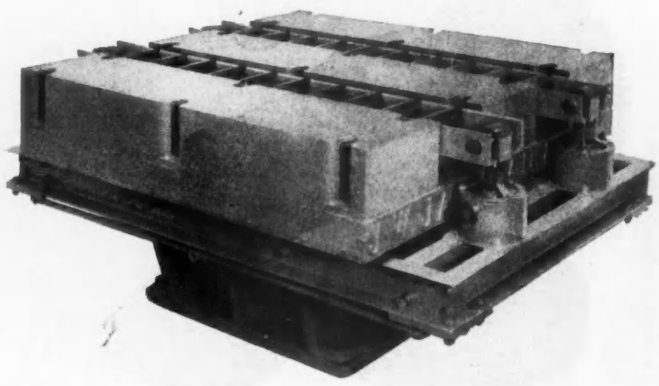

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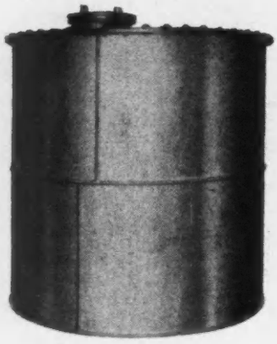

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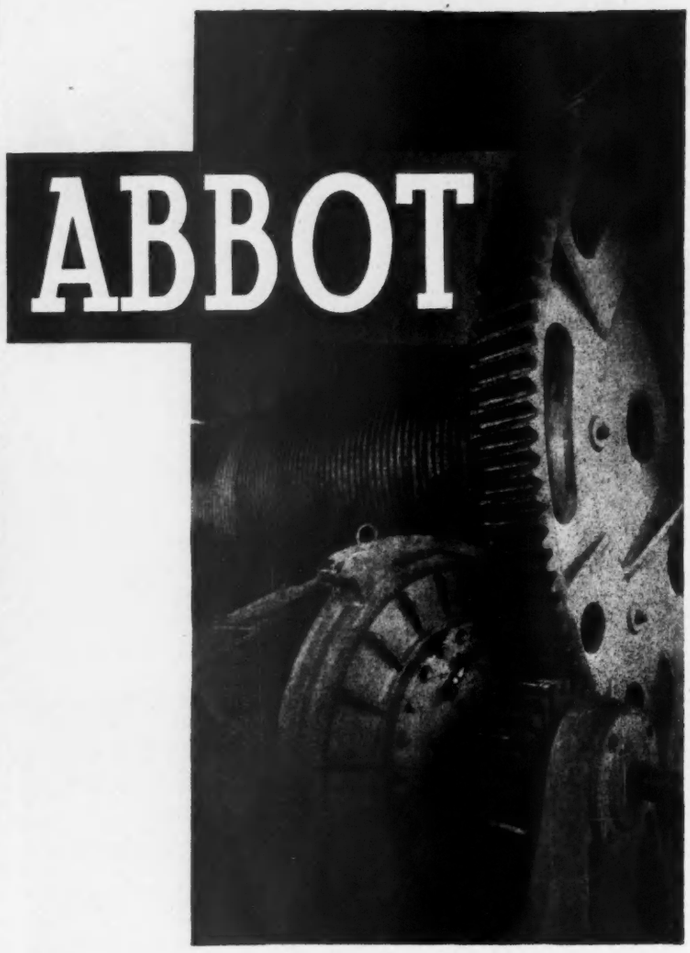

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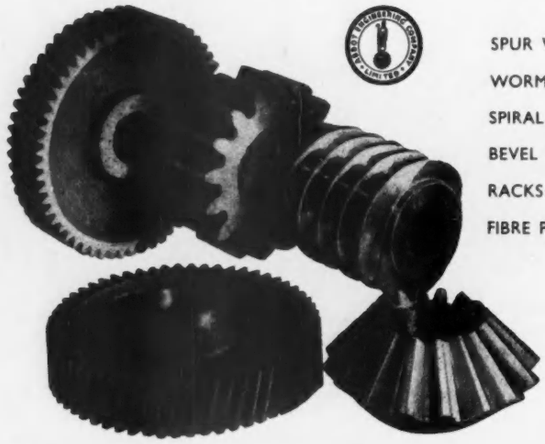

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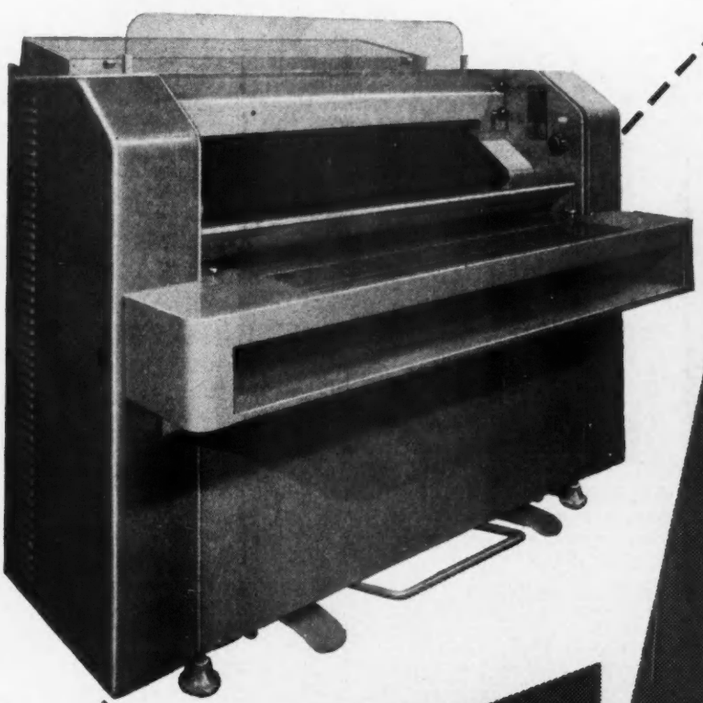

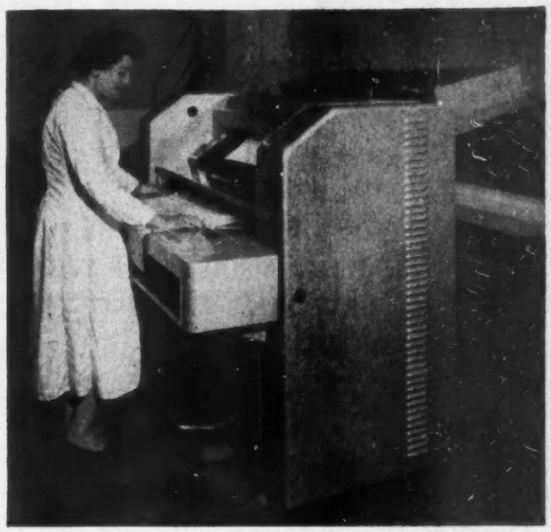

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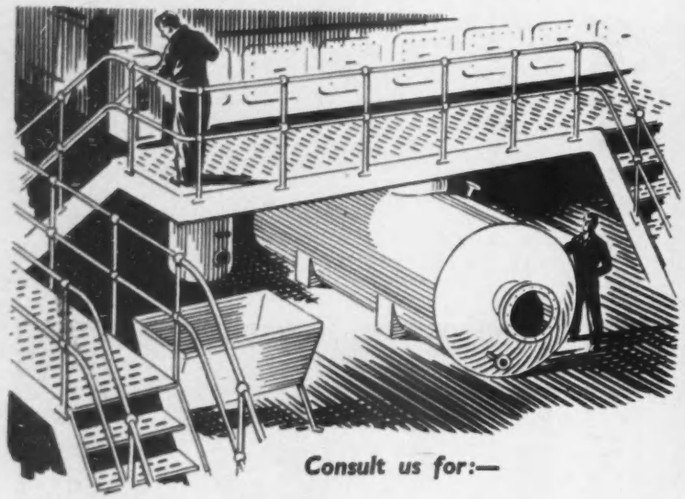

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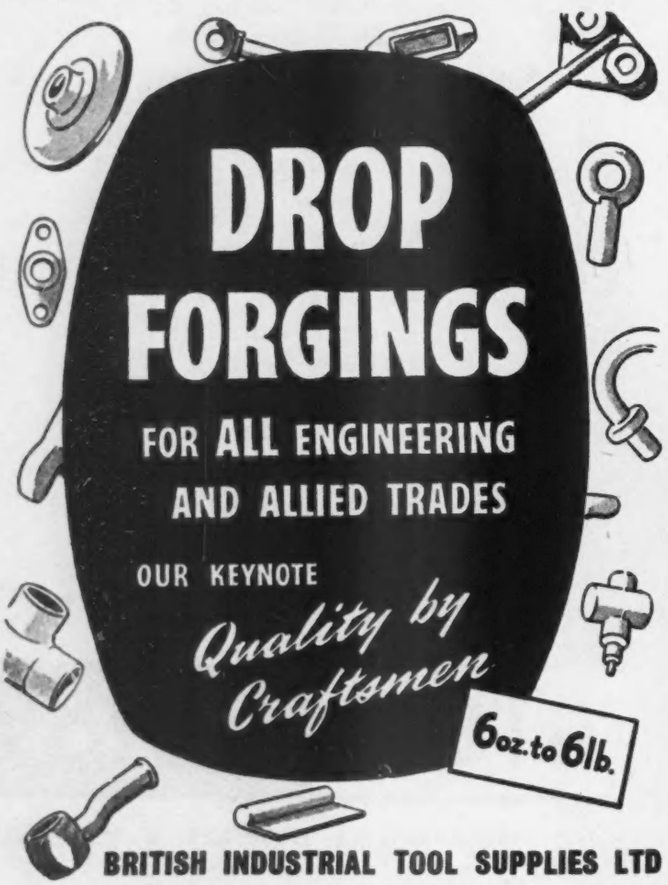

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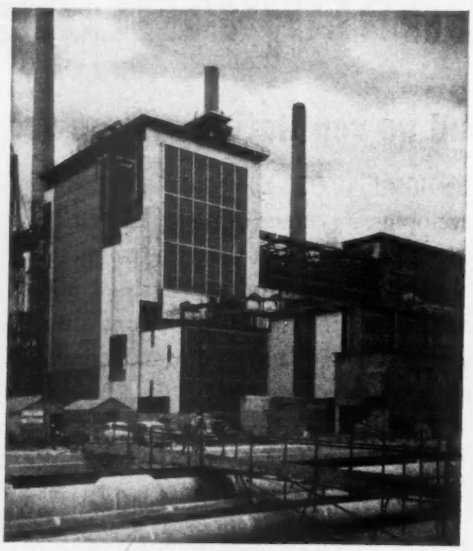

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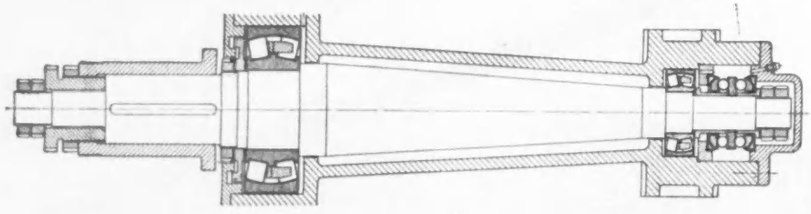
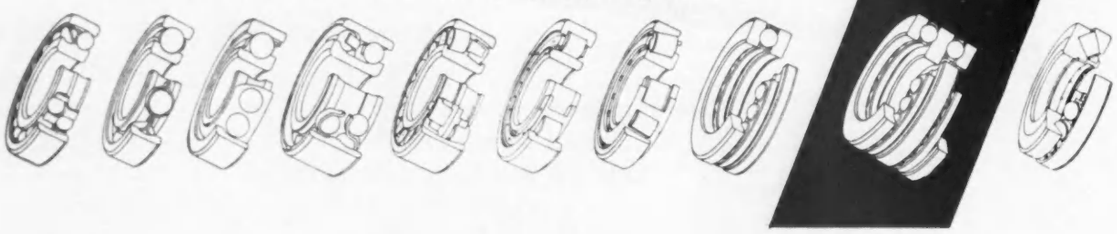


Bearing scheme for roll spindle for multi-row section straightening machine



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THE ENGINEER

No. 5404 AUGUST 21, 1959 VOL. 208

ATOMIC ENERGY UNDER SCRUTINY

One of the problems facing Britain's new and rapidly growing nuclear power industry is that it needs to be under continuously critical review to make sure that this country's limited resources are put to the best use, that her money is well spent and her manpower is skilfully deployed towards the attainment of clear objectives. Part of the industry has recently been subjected to just such a review and the result is published in a report from the select committee on estimates on the activities of what used to be known as the Industrial Group of the United Kingdom Atomic Energy Authority. It is interesting to find that the main conclusion of this committee (after the most detailed examination of the Authority by any Parliamentary committee) is that the Industrial Group has "carried out its tasks with efficiency and success," and has shown considerable cost-consciousness in developing a system for controlling expenditure on research and development. This commendation is enhanced by the fact that most of the work of the Industrial Group has been concerned with extending the frontiers of knowledge and technology. The committee has also been impressed by the readiness of the Authority and the Group to respond to changing circumstances and to criticise its own organisation and performance. Indeed, while the inquiry was in progress changes in the structure were being planned which resulted, *inter alia*, in the splitting of the Industrial Group into two new groups—one for production and the other for development and engineering. Briefly, the production group is responsible (from July 1) for the operation of the factories at Capenhurst, Springfields, Windscale, Calder Hall and Chapelcross, and for research and development concerned with these production processes. The development and engineering group is responsible for reactor design and the associated development and engineering work.

But although the committee is satisfied, on the whole, with the organisation and work of the Industrial Group it believes that the group should foster closer partnership with the industrial consortia, since the whole future of the nuclear power industry depends upon collaboration. The report points out that, in 1958–59, only about 8 per cent of the group's operating expenditure on research and development was accounted for by extra-mural contracts with industry and the universities. Most of the industrial consortia now have the capacity and the will to undertake more research work on contract and to make some financial contribution towards it. Accordingly, the suggestion is made that the value of extra-mural research work should be trebled in the next few years. In particular it is proposed that the external research work sponsored by the Dounreay establishment should be increased tenfold in the next financial year. This proposal is significant since the committee attaches very high priority to the fast breeder reactor, which, in Sir Christopher Hinton's view, "is the most important of all the development projects which the Industrial Group has in hand." Development of the fast reactor (which uses the plutonium by-product) is, therefore, regarded as being directly relevant to the success of the current ten-year programme and not merely as a long-term project for the 1970s. The technical problems to be solved are challenging, but the greatly increased development effort required is justified by the prospects of achieving a low cost system : the forecast quoted in the report is a capital cost of £75 per kilowatt installed and generation costs of 0·3d. to 0·4d. per unit on base-load working. Comparative figures for the advanced gas-cooled reactor (A.G.R.) which might be commissioned in 1967–70 are £85 per kilowatt installed and 0·5d. to 0·54d. per unit calculated on present uranium prices.

Divergence of views between the Industrial Group and the consortia is, naturally, greatest on the subject of reactor development. Many of the industrial firms would like to see the Atomic Energy Authority take the initiative in developing a small reactor suitable for export, in competition with the U.S.A., and would, according to the report, be willing to collaborate. We sympathise with this idea, provided that the proposed system offers good prospects of competing in cost with the orthodox generator. On the other hand, we appreciate the Authority's self-discipline in preferring to concentrate the effort on the most promising targets. But are these two viewpoints necessarily incompatible ? The report quotes the evidence of one witness that the industrial consortia are capable now of developing about 80 per cent of a reactor system. Might not the balance of the effort in one or two promising projects be supplied by the Industrial Group without excessive diffusion of its resources ? This argument would apply to the main industrial consortia and to the other manufacturers and shipbuilding interests which are concerned with the possibilities of nuclear propulsion. It should not be difficult to call upon some of the resources that these powerful interests command and to explore these possibilities without prejudice to the main power programme.

A FLEET IN NEED

If the special needs of the Royal Navy are anywhere discernible in the "Sea Vixen," which has now been upgraded from an interim to the final fleet defensive aircraft, despite the absence of any weapon suitable for the "slow 'plane" concept, it is in the use of two large, lightly loaded engines. It is, therefore, surprising to learn of a proposal to re-engine the "Whirlwind" helicopters, which spend much of their time flying slowly—and, therefore, at high powers—and at levels too low for the crew either to ditch under control or bale out in the event of engine failure, with a single engine of the highest specific output yet achieved. Power units comprising two free-turbine engines driving into a common gearbox were developed, though not to airworthiness standards, some time ago in this country, and would appear to offer the existing airframes much more than the ability to eschew

petrol. But, when one considers that all the most expensive parts of a helicopter have a severely limited life—fatigue of the transmission is a severe threat in the piston-engined machine—it is difficult to discover what is the attraction in the proposed modification programme ; for the example of the air lines, in which the airframe, services and furnished interior represent the bulk of the investment, is by no means relevant. Since the first of the engines suggested for use has yet to be flown, retro-fitting can hardly be regarded as a desperate remedy justified by immediate urgency. The objections become obvious when one compares the T.58-powered " Whirlwind " with the parent company's equivalent machine ; the long experience of Sikorsky with marine aircraft has borne fruit in a helicopter which is amphibious, thus eliminating losses of machines and men due to engine failure, bad fuel management, or saturation of the carrier landing-on capacity, as well as offering the possibility of recovering sonar buoys. And it is significant that the machine under development for anti-submarine work will be twin-engined.

LONDON'S TRAFFIC PROBLEMS

The Report of the Committee on London Roads, issued at the end of last month, proves to be a competent but uninspiring document. It amounts in fact to little more than an approving review of the London County Council's proposals for road improvements within London over the next 10 to 20 years. The Committee has leant over backwards in avoiding the mistake, made by certain other bodies and consultants in the past, of trying to design a more or less ideal road system irrespective of its cost. Instead, it has considered only what could be done at rates of expenditure confined to about £6,000,000 per year or to about £10,000,000 a year, the latter amounting in effect only to an acceleration in carrying out the same programme as that envisaged under the lesser expenditure. The members of the Committee, all save one of whom either come from the Ministry or are connected closely in one way or another with the London County Council, seem even to regard the larger of these two figures as a rather audacious one to contemplate. It is only regarded as being within the realms of possibility in the future if the total road programme is enlarged " to make an even bolder attack possible." Other people, having studied the rate at which the number of vehicles on the roads is increasing and having appreciated how serious congestion has become in London streets, are more likely to regard both levels of annual expenditure as decidedly timid !

But once the reader has accepted the document as a statement by civil servants cautiously rejecting anything which might be regarded as a radical proposal, it will be found to convey quite a lot of useful information. The Committee notes, for example, that the rate of increase of traffic in London is about half that for the country as a whole. It is complacent about it. It regards it as desirable to aim at so improving the road system that traffic flows more easily and safely, " but, if possible, without attracting so many more vehicles that the benefit of the improvement is lost." Is there not something awry, we wonder, with this argument ? For does not the voluntary exclusion of much traffic from London's streets due to congestion amount to a serious commercial loss to London ? Should not the better, even though a more difficult and costly, aim be to attract as much traffic to London as possible ? That is a thought which might frighten the members of the Committee. But it should not frighten the business community. Upon another tack, it is clearly the view of the Committee that in conjunction with an attack on all-day parking in the streets there ought also to be provided at an economic charge (which would prove quite high) off-street parking in multi-storey garages. But it is revealed that there exists between the L.C.C. and the Government a difference of opinion as to whether financial assistance towards the building of such garages should be supplied by the Government. Until that matter has been cleared up, the reader is driven to conclude, it is unlikely that more than a very few such garages will be built, even though the erection of several have already been planned by the L.C.C. and private concerns. Again, the report provides a revealing picture of governmental civil service thinking, national and local, upon the subject of urban motorways. The Committee shied away from any such radical projects ! It does, indeed, discuss them ; but it does so inconclusively and with emphasis on the difficulties of siting and construction, &c. It reaches no definite conclusions except that " their construction is not feasible within the foreseeable financial limits " ! This attitude contrasts strikingly with the growing conviction amongst road engineers that urban motorways constitute an essential part of any plan for relieving traffic congestion in cities.

The attitude of civil servants might suffer an interesting change were it really possible to demonstrate conclusively and financially how great a contribution towards the solution of the problem urban motorways could make. It is with that point in mind that we welcome a section of the Report which deals with traffic engineering and planning, and in particular with the sentence, " there is a great need for more traffic data for planning new and improved roads in London." There is, indeed ! And traffic engineers would be the men to gather it. Lack of information about the real extent of the problems and about the effects upon the whole of piecemeal improvement is another reason why too little and piecemeal improvement undertaken too late is preferred to anything more radical. Lacking the knowledge upon which any firm planning of radical changes could be based, the L.C.C. engineers can do nothing more than fall back upon attempts at relieving congestion locally wherever and whenever it threatens to reach intolerable proportions. What must sooner or later be produced if London is ever to get urban motorways is a document as convincing as the Beaver Report on air pollution, something which could demonstrate conclusively the immensity of the annual cost to London of not building them. Perhaps traffic engineers will be able soon to collect sufficient evidence.

BRITAIN'S DEFENCE PLAN, 1963 ?

By the end of 1962, Britain's five-year defence plan will have run its course. What is to replace it ? It is unlikely that there will be any change in the official policy of all parties in Parliament against one-sided disarmament. Equally, any proposal that this country should shelter under the umbrella of America and join a " Non-nuclear Club " holds out little prospect of success in view of the almost certain opposition from such powers as France and China. But there is little doubt that, if in the coming missile era, the rocket bases of all the NATO powers, other than the United States, were seaborne, international tension would be very greatly diminished. The Soviet leaders would no longer be obsessed with the fear of future revenge from a reunited and rearmed Germany—their principal, indeed, their only remaining, interest in Europe. And it would lessen—if not eradicate—the

anxiety felt by many people in Europe that the installation of rocket bases in their territories makes them an automatic target for Soviet missile bombardment.

At the moment the problem is to produce a seaborne rocket with sufficient range—if launched off an enemy's coast—and with sufficient amount of explosive power in its warhead to equal the performance of a land-based rocket, such as Britain's " Blue Streak " now under development. Consideration of this question is not to lose sight of the deterrent power of the bomber—whether long range or medium range or carrier based—with its guided flying bomb launched 100 miles from the target. The bomber may well provide the main allied deterrent power for the next five or even ten years. But ships take a long time to design and build and ships planned in 1963 would not be in commission before the missile era is upon us. The Americans have for some years earmarked a substantial part of their naval strength to supplementing the land-based deterrent. They have nine very large carriers capable not only of operating heavy bombers with a range of 1000 miles, but of launching the 1000-mile " Regulus " guided flying bomb. Many of their smaller " Essex " class carriers and two or three submarines are also equipped to launch this guided missile, and a heavy cruiser is now under construction with an armament entirely composed of guided weapons.

The primary object of the navies of Britain and other European powers, however, is to safeguard the sea communications. If their ships are also to be used for deterrent purposes, the equipment for manipulating the deterrent weapon must not add to the extensive and complicated installations already required for guiding the anti-aircraft missile near to its target. It must, in fact, be a ballistic rocket which has no recoil and requires only the inertial navigational equipment to fix exactly the position of firing. Thus the adoption of seaborne instead of land-based rockets would seem to depend on the state of development of the naval " Polaris " rocket in 1963. This missile can be launched both from surface ships and submarines, but it is at present being developed for firing from submerged submarines. After the firing tube hatch has been opened, a plastic diaphragm immediately above the missile keeps the missile dry. Air pressure inside the tube equalises outside water pressure. The missile is fired through the diaphragm and an automatic water compensation system compensates for the change in weight.

According to well-informed United States sources, however, its extreme length is not more than 46½ft This is a relatively small rocket even in comparison with the 65ft land-based " Thor," which has a range of 1500 miles. Indeed, there seems to be some doubt whether the range of 1200 miles anticipated for the " Polaris " has not been overestimated. It is, in any event, clear that the warhead which a 46ft missile can carry is not large enough to compensate for the inherent inaccuracy of a ballistic rocket. None the less, the size of the launching tubes in the submarine provides for the development of larger versions of the " Polaris." With the constant progress in science and engineering it may well be that by 1963 a naval missile will be available which, because of the shorter effective range when launched from ships and the saving of vast expenditure on concrete underground sites, may compare very favourably with the land-based " Blue Streak." The United States naval authorities have certainly no doubt about its possibilities. Six 5400-ton submarines of the " George Washington " class are now building, three more have been authorised and in accordance with the present programme, the U.S. Navy plans to have forty-five ballistic missile submarines built or under construction within the next five years. Congress has already allocated over 2000 million dollars for the development and construction of the nine vessels already authorised, while at the same time cutting down the demands of the Army and Air Force for improvements in the anti-aircraft guided missile defences of the American Continent.

Britain and other European powers cannot afford to build submarines, each costing £36,000,000, solely to act as a deterrent. But is there any technical reason why surface ships should not be built to carry out a dual role? A gun and anti-aircraft guided missile armament could be installed in the forepart for the defence of the sea communications, with the afterpart earmarked for the stowage and launching of rockets. A surface warship, being mobile, would have the same immunity as a submarine from guided missile attack. Protection from submarine and manned bomber attack would, of course, be required, as, indeed, it is for other surface warships employed in safeguarding the sea communications. Possibly, however, the difficulty of launching a missile accurately upon the desired course from the moving platform of a surface ship in any kind of seaway is insurmountable. If so, the ship would have to be so constructed that it could be beached like a landing craft for the purpose of launching missiles. We have deliberately taken risks in making sure that our anti-aircraft guided missile development was on the right lines before starting production and this has turned out a wise policy. Unlike the United States defence chiefs, who are still arguing about the best missile for defence against the manned bomber, the British Chiefs-of-Staff are quite satisfied that our own A/A missiles are well suited for this country's requirement. But is " Blue Streak " exactly the weapon we need as a continuing contribution to the deterrent ? Would not a ship-borne missile be preferable ?

The Engineer—100 Years Ago (AUGUST 19, 1859)

" BOYDELL'S TRACTION ENGINE "

" On Thursday and Friday last, the 11th and 12th inst, an engine and train of five wagons, the first of two ordered by the Government from Mr. Boydell, for India, were worked during both days in Hyde Park, to the great satisfaction of an immense crowd of gentry and others interested in the matter. The engine had two 8-in. cylinders, and wrought-iron driving-wheels 7 ft. in diameter, with the endless railway attached to them ; she has the link motion and the usual fittings of a locomotive engine, and is a great improvement on the former engines in all respects.

" The five wagons when empty weigh about 3 tons each, and have been well made by Messrs. A. and E. Crosskill, whose name is a sufficient guarantee for the quality of the work. The peculiarity in these wagons consists in their being so arranged that they follow in an exact line, whether turning or going on the straight, with a very pleasing regularity, and this is obtained by placing the pin connecting the fore-wheels to the body of the wagon at a point near the middle of its length, and keeping the distance between each wagon exactly alike ; consequently, in turning they follow as truly as if they were on a rail. When going straight, a small pin attached to the front of the wagon, raised or depressed by a small lever, is inserted in a hole in the front carriage of the wagon, so that all oscillation is thus prevented, and the train becomes, as it were, one large wagon, and the pin only requires removal when a turn is to be made. Each wagon when loaded will carry 4 tons, and the engine herself weighs about 12 tons."

Power for the Long-Range Supersonic Airliner

No. II—(*Concluded from page 58, August 14*)

At the Summer Meeting of the Institute of the Aeronautical Sciences in Los Angeles last June, Dr. R. R. Jamison, head of the ramjet department of Bristol Siddeley Engines, Ltd., presented a lecture expounding the applicability of integrated turbo-jet/ramjet power plant. We reproduce the greater part of this lecture.

Power Plant–Airframe Optimisation

UP till now we have been examining the behaviour of supersonic power plants without taking into account the mutual influence of the power plant and the airframe on each other when they are being matched to give the optimum performance for a specified application in a supersonic transport aircraft. In the preceding section a representative airframe performance has been assumed in order to make general power plant comparisons, but a true assessment and optimisation study requires a more systematic attack with complementary variation of the airframe and power plant specifications. This process has to be undertaken within the scope of the requirements which must be met to make the aircraft suitable for commercial operation. The following assumptions have been made on the operational requirements :

Stage length, 3100 nautical miles against 40 knots head wind.

Take-off, balanced field length, 7000ft.

Fuel reserves for (*a*) 20 nautical miles diversion ; (*b*) stand-off for forty-five minutes at 20,000ft ; (*c*) stand-off for fifteen minutes at 5000ft ; (*d*) unusable fuel remaining in tanks.

The variables which have been considered in this analysis are :

1. Airframe : (*a*) wing loading ; (*b*) aspect ratio ; (*c*) structure weight ; (*d*) lift-drag ratio.

2. Engines : (*a*) installed thrust at take-off ; (*b*) installed thrust for cruise ; (*c*) engine type (turbo-jet, reheated turbo-jet or combination) ; (*d*) operating tailpipe temperature ; (*e*) installed weight.

3. Operation : Cruise altitude.

Type Aircraft.—The general aircraft specification has been taken around a " nominal aircraft " whose leading data are :

All-up weight	300,000 lb
Cruise Mach number	3·0
Start of cruise altitude	70,000ft
Lift-drag ratio (cruise)	8·35
Thrust-weight ratio (take-off)	0·34
Wing loading at take-off	40 lb per square foot
Aspect ratio	2·0
Structure weight plus systems weight	35 per cent of all-up weight
Engines	Combination engine
Balanced field length	6000ft

The general configuration of this machine is shown in Fig. 7. On the specification given above this " nominal aircraft " would have a payload of 24,000 lb=8 per cent, on the 3100 nautical miles stage length with allowances. This " nominal aircraft " has been taken as the type aircraft in our optimisation study. The same basic configuration has been maintained but variations of wing area and aspect ratio have been taken either above or below the nominal values. The associated changes in lift-drag ratio and structure weight have then been computed, so the analysis is based on a family of aircraft, derived from the nominal aircraft, having a systematic and compatible variation of their performance parameters. (The lift-drag ratio is also a function of the operating altitude and this has been allowed for.)

Power Plants.—The following assumptions have been made for the power plant components :

Intake :
Variable angle of attack, isentropic wedge, two-dimensional intake.
Design Mach number ... ... 3·0
The characteristic performance curve is given in Fig. 8.

Ramjet :
The thrust performance behind the above intake assumes a combustion efficiency of 95 per cent.

Ramjet weight	0·68 lb per square inch of duct area (including variable nozzle)
Cruise tailpipe temperatures	980 deg. K. to 1150 deg. K. (1760 deg. R. to 2070 deg. R.)
Cruise specific consumption	1·64 lb/lb hour

Turbo-jet :

Compressor pressure ratio	5·5 : 1
Take-off turbine entry temperature	1250 deg. K. (2250 deg. R.)
Cruise turbine entry temperature	1200 deg. K. (2160 deg. R.)
Nominal take-off thrust	16,000 lb
Nominal weight, including variable nozzle	3,250 lb
Weight per square inch of enclosing duct	1·74 lb
Specific fuel consumption at $M=3$ in stratosphere	1·64 lb per hour lb

Reheated turbo-jet :
Basic assumptions as for the turbo-jet above but with a weight increase of 22 per cent for the reheat equipment.
Cruise specific consumption at $M=3$ in stratosphere :

Tailpipe temperature	1200 deg. K. 2160 deg. R.	1400 deg. K. 2520 deg. R.	1600 deg. K. 2880 deg. R.
Specific consumption, lb/hour/lb	1·81	1·92	2·10

Procedure.—We can now proceed to establish comparisons of aircraft-power-plant combinations matched to get the best performance within the operational requirements. The answer will emerge as the payload capacity, which can be taken as the principal figure of merit as it represents the revenue capacity of the design. Other factors will, of course, have to be considered in making a final choice on the specification to go for, as, for instance, initial and operating costs, the cost and time of development, and operational flexibility.

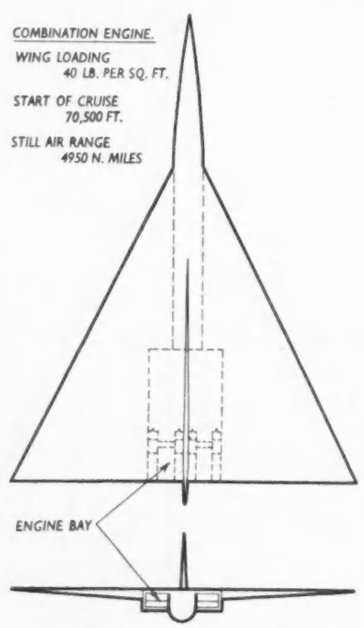

Fig. 7—Nominal $M=3{\cdot}0$ aeroplane, diagrammatic layout

Figs. 9 and 10 show typical plots of the lift-drag ratio as a function of aspect ratio and wing loading, each for a chosen start of cruise altitude using variations on the type aircraft. From these curves and from general considerations an aspect ratio of 2·0 has been chosen for the rest of the investigation and in Fig. 11 the derived values of the peak lift-drag ratios for an aspect ratio of 2·0 have been plotted against start of cruise altitude, together with the associated wing loadings. This variation of wing loading implies a change in wing structure weight relative to the total structure weight for, over the altitude range, we have the wing area increasing with altitude although there will be a corresponding fall in flight dynamic pressure. The estimated effect of these variables on the parameter $\frac{\text{(structure + systems) weight}}{\text{take-off weight}}$ is shown in Fig. 12.

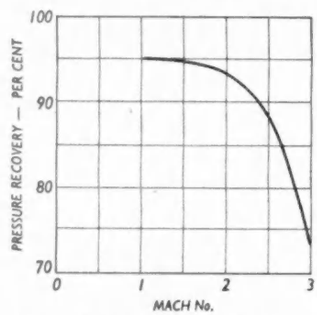

Fig. 8—Intake total pressure recovery

Engines.—We have so far considered a family of airframes all to the same all-up weight, specified to fly the same stage length with allowances at $M=3$, with the wing loadings adjusted to the cruise altitude to give optimum L/D during cruise. We now have to consider the engines. Using the plot of cruise L/D against cruise altitude in Fig. 11, the total net thrust required from the power plant at each start of cruise altitude is obtained as $\frac{W_1}{L/D}$, where W_1, at 270,000 lb, is taken as the weight at the start of cruise, after allowing 30,000 lb fuel for take-off and climb. Knowing the cruise thrust and the characteristics of the engines we can now specify how much engine of each type must be installed just to match the thrust demand and, at the same time, we obtain the engine airflow and the duct size. Fig. 13 can then be drawn, which shows the variation of the percentage of engine plus fuel weight against start of cruise altitude for each kind of engine. The fuel weight is the total weight of fuel (with allowances) for the complete mission and not merely the fuel consumed during cruise. Marked on the curves are " points of cut-off," which represent the cruise altitudes at which the power plants to match the cruise thrust demand would also provide enough thrust to meet the specified take-off performance. In the case of the combination engines the proportion of turbo-jets was chosen to give a fixed thrust at take-off equal to that specified in the " type aircraft," but owing to the higher wing loadings at low cruise altitude

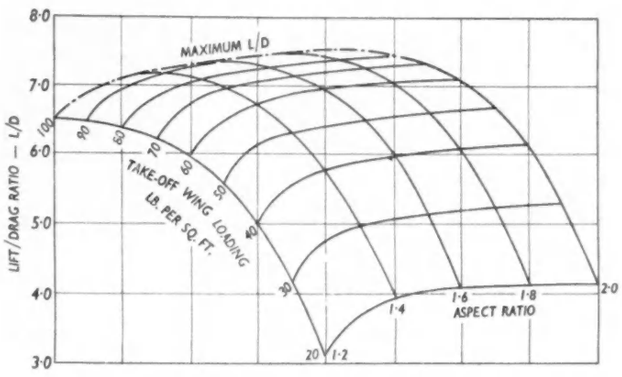

Fig. 9—Lift drag ratio : 55,000ft, $M = 3 \cdot 0$

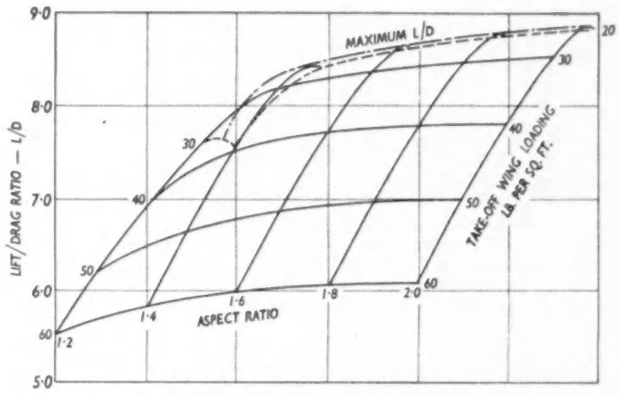

Fig. 10—Lift drag ratio : 85,000ft, $M = 3 \cdot 0$

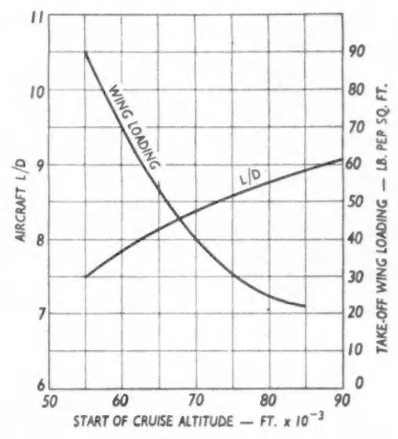

Fig. 11—Aircraft lift drag ratio and wing loading

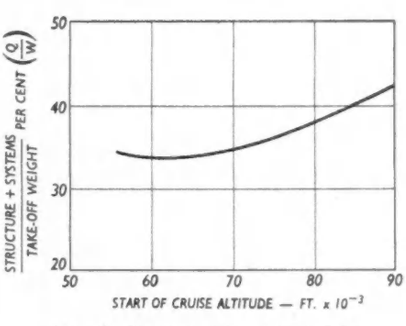

Fig. 12—Structure and systems weight

the " nominal take-off performance " would not be met below the cut-off point. If extra engines were installed to meet the required take-off performance in an aircraft having a low cruise altitude, their weight would be a direct charge on the payload. The variation in the proportions of ramjet and turbo-jet as duct area, is shown in Fig. 14 as a function of start of cruise altitude.

The payload can be obtained by combining the data from Figs. 12 and 13 to give Fig. 15 which shows a plot, for each power plant type, of the weight of (engines + fuel + structure + systems) as a percentage of all-up weight.

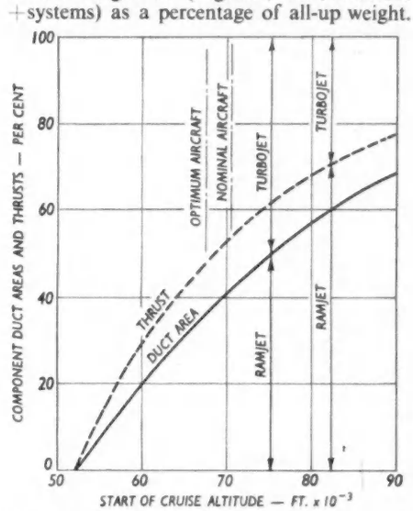

Fig. 14—Combination engine relative duct areas and thrusts for the turbo-jet and ramjet

The amount by which this parameter is less than 100 per cent gives the payload for the mission. A breakdown of the component weights at the best payload point for each power plant shows that the combination power plant which achieves a payload of 9·0 per cent is significantly better than its nearest competitor, the turbo-jet without reheat, at 6·7 per cent. This value of 9 per cent on a 300,000 lb aircraft represents a payload of 27,000 lb, equivalent to about 130 passengers. To complete the picture these payload figures have been turned into direct operating costs. The absolute values of these costs could be the subject of some argument for the method of utilisation of a 1700 knot transport has yet to be worked out, but, nonetheless, these figures have been calculated on reasonable operating assumptions and can form the basis of comparisons with current projects.

In addition to the assumptions made in developing the performance analysis the following factors have been taken :—

Utilisation	3000 hours per year
Life	10 years
Airframe cost	£20 (56·6 dollars) per lb
Engine cost	£20 (56·6 dollars) per lb

The resulting direct operating cost figures are tabulated in Fig. 16, where the D.O.C. for the combination engined machine comes out at 12·4 cents per short ton statute mile compared with a 33 per cent higher figure for the best all-turbo-jet at 16·4 cents. The assumptions in the costing procedure most likely to be queried are the costs of airframe and engines and the utilisation figures. (Further figures showed that either the airframe or engine costs could be doubled

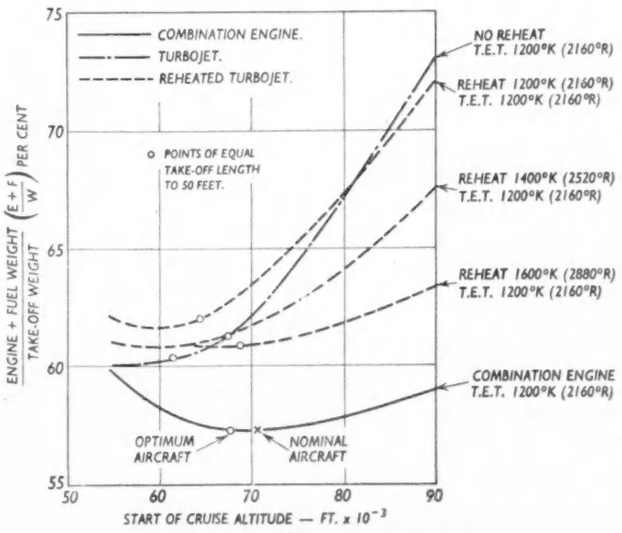
COMBINATION ENGINE.
TURBOJET.
REHEATED TURBOJET.
POINTS OF EQUAL TAKE-OFF LENGTH TO 50 FEET.
NO REHEAT T.E.T. 1200°K (2160°R)
REHEAT 1200°K (2160°R) T.E.T. 1200°K (2160°R)
REHEAT 1400°K (2520°R) T.E.T. 1200°K (2160°R)
REHEAT 1600°K (2880°R) T.E.T. 1200°K (2160°R)
COMBINATION ENGINE T.E.T. 1200°K (2160°R)
OPTIMUM AIRCRAFT
NOMINAL AIRCRAFT
ENGINE + FUEL WEIGHT / TAKE-OFF WEIGHT (E+F)/W PER CENT
START OF CRUISE ALTITUDE — FT. x 10⁻³

Fig. 13—Engine + fuel weight

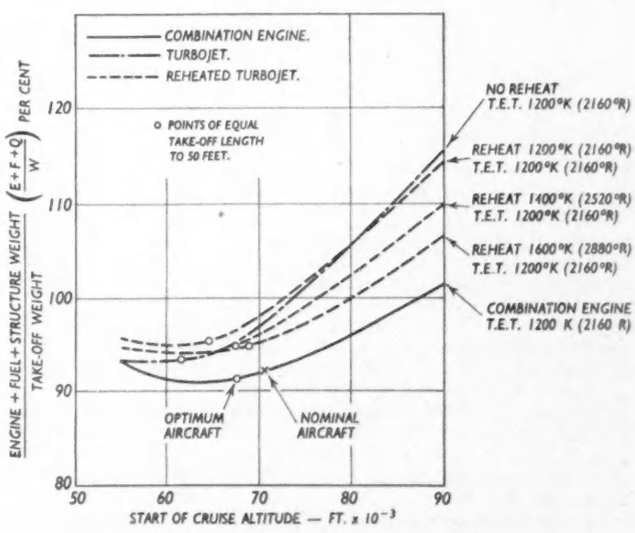
COMBINATION ENGINE.
TURBOJET.
REHEATED TURBOJET.
POINTS OF EQUAL TAKE-OFF LENGTH TO 50 FEET.
NO REHEAT T.E.T. 1200°K (2160°R)
REHEAT 1200°K (2160°R) T.E.T. 1200°K (2160°R)
REHEAT 1400°K (2520°R) T.E.T. 1200°K (2160°R)
REHEAT 1600°K (2880°R) T.E.T. 1200°K (2160°R)
COMBINATION ENGINE T.E.T. 1200 K (2160 R)
OPTIMUM AIRCRAFT
NOMINAL AIRCRAFT
ENGINE + FUEL + STRUCTURE WEIGHT / TAKE-OFF WEIGHT (E+F+Q)/W PER CENT
START OF CRUISE ALTITUDE — FT. x 10⁻³

Fig. 15—Engine + fuel + structure weight

without reaching the turbo-jet level, or the utilisation dropped to 1500 hours in each of seven years.—Ed., THE E.).

INSTALLATION

From this study of the supersonic transport from the power plant aspect three main conclusions have emerged :—

(1) The design cruising speed should be about 1720 knots (Mach 3) to secure a good compromise between economic operation and engineering problems.

(2) In this speed range it is important to integrate the power plant into the airframe design.

(3) The best power plant to use is the turbo-jet-ramjet combination unit.

It is now of interest to look at some of the engineering considerations that arise in applying these principles to an aircraft design.

The suggested basic form of engine duct has already been referred to and is shown in Figs. 4 and 5 (*ante*). The essential elements are :

(*a*) A rectangular section with upper and lower surfaces which can be integrated with the aircraft wing surfaces.

(*b*) A variable intake using a two-dimensional isentropic wedge. The intake wedge angle of inclination can be varied to minimise pre-entry and cowl drag when operating below design speed.

(*c*) A common diffuser duct feeding air to a number of engines mounted within it.

(*d*) Turbo-jet and ramjet engines mounted in parallel and drawing air from the common diffuser duct.

(*e*) Convergent-divergent, two-dimensional variable nozzles.

Three possible layouts of an aircraft using such an integrated combination engine

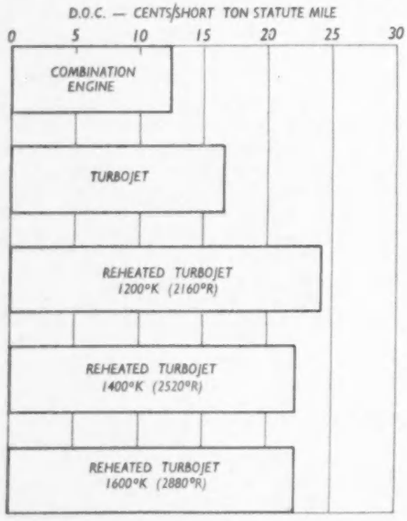

Fig. 16—Comparison of direct operating costs

power plant duct are suggested in Fig. 17. In type I in this figure a twin fuselage arrangement is shown which gives the power plant engineer a clear field to install the engines to the best advantage. A more conventional approach with a single fuselage is shown in type II. Type III is an advanced concept in which fuselage drag is eliminated by housing the payload within the contour of the diffuser wedge. The aft position of the engines in these layouts allows good diffusion from the intakes and would minimise noise within the aircraft.

An impression of the aircraft is given in Fig. 18.

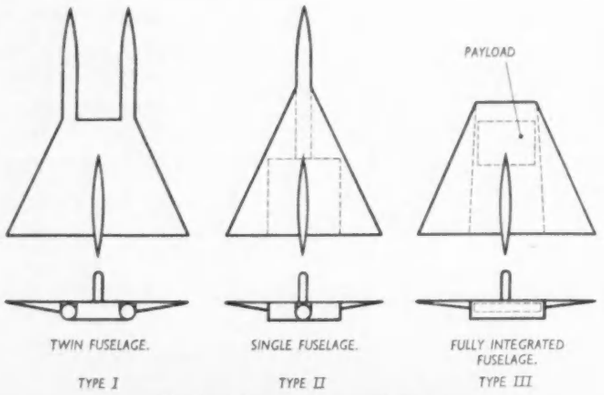

Fig. 17—Diagrammatic aircraft layouts

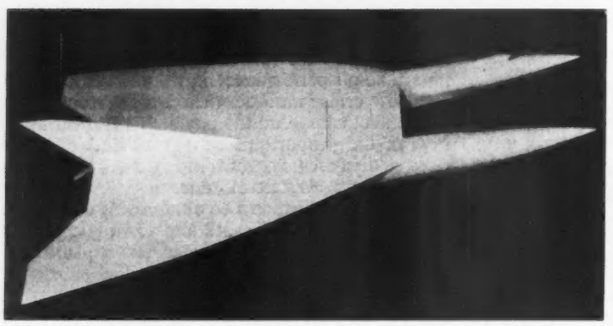

Fig. 18—Model of proposed aircraft

OPERATION

The general operational procedure with a combination power plant will not differ markedly from that applying to pure turbo-jet installations ; the ramjets do, however, confer greater flexibility. Up to transonic conditions the aircraft would rely entirely on turbo-jet power and the engines would be handled in a normal manner for taxi-ing, take-off, climb or descent and landing. During this phase the ramjets would be cold and would have their propelling nozzles closed to keep down drag. The ramjets would be lit during the climb, probably at $M=0{\cdot}8$ to $0{\cdot}9$ at about 20,000ft to 25,000ft altitude, and would be adjusted to a high thrust condition, the actual power being suited to the required climb path. In general the minimum consumption of fuel during climb is obtained by climbing at maximum thrust on both turbo-jets and ramjets, but quite a wide choice of climb path is available without compromising the range. In practice other factors than range may dictate the climb regime. One is the need to acquire enough altitude before going supersonic to avoid nuisance from "sonic bangs." Others might derive from the very high mean rate of climb available (of the order of 8000ft per minute). This may have to be limited to keep the rate of change of cabin pressure and possibly also the aircraft attitude within acceptable values. A typical altitude-Mach number relationship is shown in Fig. 19 together with a graph of the intake duct pressure which gives a good indication of the way the aerodynamic forces vary with altitude ; as can be seen, the duct pressure keeps reasonably constant. Fig. 20 is an equivalent plot of the thrusts and drag during climb which shows the contributions of the power plant components on a relatively easy climb. (Sixteen minutes to 70,000ft.)

Fig. 20 also shows the variation in ramjet tailpipe temperature between 1670 deg. K. (3000 deg. R.) for maximum thrust and 1150 deg. K. (2070 deg. R.) for cruise. This draws attention to a most valuable attribute of a ramjet engine which is the great reserve of thrust available above the cruise rating. This makes the combination engine extremely flexible in operation and derives from the fact that although the ramjets, during cruise, are operating at a low tailpipe temperature of 980 deg. to 1150 deg. K. (1760 deg. to 2070 deg. R.), 1800 deg. K. (3240 deg. R.) could readily be available which would double the ramjet thrust and increase the total thrust by 60 per cent. Another advantage is that it is fully practicable to throttle back the turbo-jets during cruise to half-stress conditions which should be a worthwhile contribution to reliability, especially as the running conditions at $M=3$ are made more arduous by the high ram temperature. On the other hand, with a pure turbo-jet power plant, the engines would require to be run continuously at the full cruise rating and there would be very little thrust reserve.

FUTURE DEVELOPMENT

Our detailed discussion of a supersonic transport project has been conducted around a 1720 knot $M=3$ concept. This speed was chosen on the basis that it is the lowest value which will offer good economic prospects while keeping the engineering

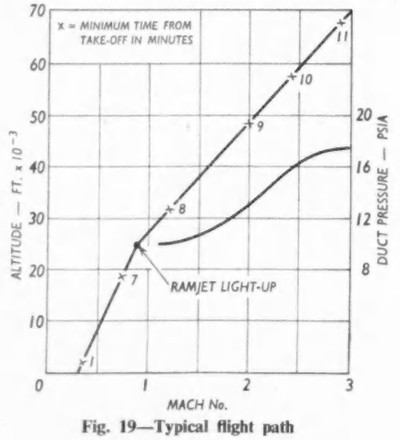

Fig. 19—Typical flight path

problems to a minimum. However, it is apparent from Figs. 3 and 6 that a continuous improvement might be expected by going to higher speeds up to at least $M=5$, although the structural and cabin conditioning problems occasioned by kinetic heating would be becoming severe. This is an added and important factor which should be kept in mind in designing a supersonic transport, for if a right initial decision is taken on the aircraft specification a prospect

is offered of a smooth and continuous development to higher capabilities in speed, range and payload by normal engineering techniques. A Mach 3 transport design with an integrated combination engine power plant and a steel airframe would offer such a prospect. The combination engine in particular would be most suitable for development for use at speeds up to $M=4$ or 5 for its characteristics are such that the turbo-jets may be shut down completely during cruise without loss of overall performance at speeds above about $M=3{\cdot}5$ while the ramjets would still be well within their capabilities. This would eliminate the need to develop turbo-jets able to cruise continuously above $M=3$, which would be a tough engineering problem.

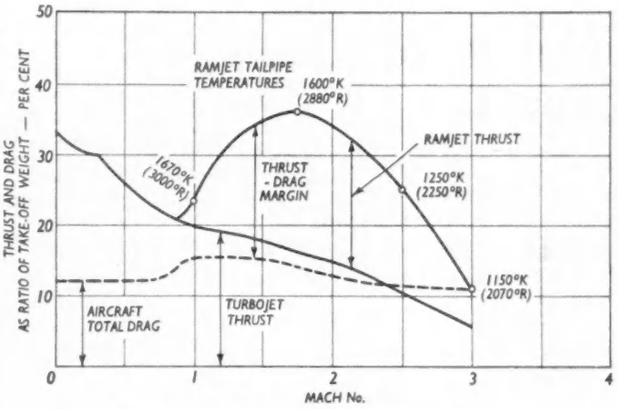

Fig. 20—Thrusts and drags on the climb flight path

Weight breakdown	Weight	Percentage
All-up weight	300,000	100
Structure and systems	102,000	34
Propulsion :		
Turbo-jet	25,200	8·4
Ramjet		
Fuel	145,800	48·6
Payload	27,000	9

Fuel usage	Weight, fuel lb	Percentage, all-up weight
Total fuel	145,800	48·6
Taxi and take-off : climb to start of cruise : $M=3{\cdot}0$, 67,500ft	30,300	10·1
Cruise	75,850	25·3
Let down, taxi and landing	5,400	1·8
Reserves : Diversion 20 nautical miles : $M=0{\cdot}8$ stand-off at 20,000–30,000ft, 45 minutes $M=0{\cdot}4$ stand-off at 4000ft, 15 minutes Reserve tankage, 1½ per cent of fuel load	34,250	11·4

Flight Plan

Flight breakdown	Time in minutes	Range in nautical miles
To start of cruise	10 (minimum)	100
To end of cruise	100	2,900
To landing	10 (minimum)	100
Total	120	3,100

Conclusion

If we look at the foregoing results of our inquiry into the best power units to use for the long-range supersonic transport aircraft the following salient points emerge :

1. The engines and airframe have to be closely matched to each other to secure optimum performance.

2. For aerodynamic, thermodynamic and engineering reasons a cruise speed of 1720 knots ($M=3$) is selected to secure economic operation over a transatlantic stage.

3. The high engine airflows required for supersonic propulsion require a ducted power plant installation closely integrated into the airframe.

4. The optimum power plant is a combination of turbo-jets and ramjets. Ramjets by their lightness, high cruise efficiency, simplicity and low cost confer significant advantages in payload, low operating cost and operational flexibility.

5. An aircraft designed to the above specification would have the following capability :

Cruise speed	1720 knots
Stage length with reserves	3100 nautical miles
Payload	27,000 lb
Direct operating cost	12·4 cents per short ton statute mile

6. Such an aircraft, while offering a threefold increase in speed, would show operating costs competitive with those of the best current projects.

7. This Mach 3 transport with a steel structure and a combination turbo-jet-ramjet power plant could be designed and built within the scope of existing engineering techniques.

8. This basic design would have a development potential, by normal engineering methods, up to speeds in the range of 2500 to 3000 knots, with substantial gains in range of payload.

APPENDIX

Optimum Aircraft Specification

General description :	
Delta-wing	Partially integrated two-dimensional combination propulsion system
All-up weight at take-off	300,000 lb
Payload	27,000 lb (130 tourist passengers)
Still air range	4950 nautical miles, including climb to $M=3{\cdot}0$, 67,500ft, i.e. stage length—3100 nautical miles with reserves
Balanced field length	7000ft at 12 deg. maximum incidence
Wing loading	46 lb per square foot
Take-off thrust weight ratio	0·34
Cruise L/D	8·25
Cruise thrust :	
Ramjet	48·5 per cent
Turbo-jet	51·5 per cent

Report on Atomic Energy

The fifth report of the Select Committee on the United Kingdom Atomic Energy Authority (Production Group) and Development and Engineering Group, has been published (price 5s.) by Her Majesty's Stationery Office.

In its inquiries the Select Committee heard evidence from the chairman and members of the Authority, members of the management board of the Industrial Group, Sir Christopher Hinton (chairman of the Central Electricity Generating Board) and members of the five consortia of industrial firms formed to build nuclear power stations for the generating boards and to exploit nuclear power in Great Britain and overseas. Visits were made to the headquarters at Risley and other establishments of the Industrial Group.

Conclusions

The main impression is that the Industrial Group has carried out its tasks with efficiency and success. This could easily have been otherwise, in an organisation which has been forced to grow so rapidly and which, in most of its work, has been breaking new frontiers of knowledge and technology. The committee is, in general, satisfied with the way that the Group has tackled a succession of novel problems and the cost-consciousness it has shown in the development of a modern system for controlling expenditure.

Military requirements are now ceasing to be the predominant influence in the Group's work. As the volume and diversity of its civil responsibilities increase there is greater need for strong central control over the major features of the Group's expenditure and expansion. The growing emphasis on reactor development and commercial activities makes it more important to bring industry into partnership with the Group so as to obtain the greatest economic value from the scientific and capital resources which exist in this specialised field. The growth of nuclear science could tempt the Group to spread its effort over too many projects. The Authority must be prepared to study and exploit fundamental new ideas. Nevertheless, the Group has made great advances by concentrating its effort on a narrow front and it will be necessary for it to continue to be selective in its choice of reactor systems for actual development, if it is to concentrate enough resources on a given project to achieve decisive results.

Summary of Recommendations

1. The increased status and responsibilities of works general managers should be recognised in a way that will ensure that these posts attract men of the high calibre required.

2. The Authority should consider whether more formal arrangements are required for the co-ordination of the work of the Production, and Development and Engineering Groups after the present arrangements have been tried over a reasonable period.

3. In view of the recent increase in the number of separate research and development organisations within the Authority, the system of co-ordinating the work being done at the various laboratories in order to avoid duplication or lack of proper balance, should be reviewed after a reasonable period of experience.

4. The Industrial Group should review its procedures to determine whether the early budgets, which are prepared by the separate establishments as the foundation for the Group's first consideration prior to formulating the actual estimates, could be simplified, so that detailed estimating need not begin as early as May of each year.

5. All applications for sanction of capital projects connected with the development of new reactor systems should include rough forecasts of any further expenditure that might eventually have to be borne by the Authority.

6. The Treasury should always be informed of the size of the contingency allowance in a project estimate, and their further sanction should be sought on the basis of detailed and firm estimates for the expenditure of any part of the contingency allowance which forms a significant proportion of the total estimate.

7. It should be standard practice in the future to allow design offices sufficient time to go out to tender for all the major components of large civil reactor and plant projects.

8. The Industrial Group should take advantage of changes in the attitude of industry and in the nature of its own work in recent years by further reducing the number and value of contracts for which competition is dispensed with.

9. The priority of the fast reactor should now be given special consideration.

10. The research and development work of the Group, which is directed to achieving improvements in the operating performance of reactors currently under construction for the C.E.G.B., should, wherever possible, be confined to those problems that the C.E.G.B. and the consortia are not equipped to deal with.

11. The Industrial Group should invite the consortia to attach a limited number of people to experimental reactor projects, and should take positive steps to make sure that the consortia are quickly aware of the progress of work.

12. If no experimental reactor is to precede the prototype stage of a system, the Group should invite the consortia to join it in discussions as soon as feasibility studies are complete.

13. When further expansion of fuel element fabrication plant is required, the Authority, the Generating Boards and the consortia should jointly consider the possible advantages of these facilities being provided and operated by others than the Authority.

Sixty Years of Armoured Car Development

By R. M. OGORKIEWICZ, M.Sc. (Eng.), A.C.G.I., D.I.C., A.M.I.Mech.E.

In June there passed the sixtieth anniversary of the appearance of the armed motor vehicle which represented the first practical step in the evolution of the armoured car and armoured fighting vehicles in general. The following article commemorates the event and reviews the development of armoured cars from their origin to the present time.

A REPORT published on these pages sixty years ago on the occasion of an Automobile Club show held at Richmond, Surrey, drew attention to the appearance there of a motor vehicle adapted to military purposes.[1] The event failed to attract wider notice in the contemporary press and the vehicle frequently has been ignored in historical literature, but it represented, nevertheless, the first practical step in the evolution of the armoured car and fighting vehicles in general.

The vehicle which thus marked the beginning of the development was a quadricycle of the popular de Dion-Bouton type, powered by a 1½ h.p. engine, which had been fitted with a light model of the Maxim machine gun and a bullet-proof shield mounted on a tripod in front of the handlebars. The combination was devised by F. R. Simms, one of the pioneers of British motoring and founder of the Automobile Club of Great Britain and Ireland—now the R.A.C.—at whose Richmond show the armed quadricycle was exhibited in June, 1899. Simms called it a " motor scout " and demonstrated it personally, going through the motions of firing the gun on the move or standing by the side of the vehicle (Fig. 1).

Viewed in the perspective of sixty years, the appearance of a machine gun armed vehicle, such as this, was a logical and inevitable step forward from earlier developments and, in particular, from attempts at increasing the mobility of the machine gun, which Hiram Maxim had recently developed. One such attempt, along traditional lines, took the form of a " galloping gun carriage," a light horse-drawn vehicle which was designed by Lord Dundonald and fully described in a contemporary issue of THE ENGINEER[2]; another attempt consisted of mounting two Maxim machine guns on the back of a two-seat pedal tricycle.[3] Thus, it was largely a matter of time before someone also tried mounting a machine gun on a motor vehicle, although Simms still deserves credit for his initiative.

The fact that Simms's armed quadricycle was part of a general trend is illustrated by another report on these pages, in September, 1899, that a " motor gun carriage " was being built in Peoria, Illinois.[4] This first American armed motor vehicle was a three-wheeler, which carried a Colt machine gun and, like Simms's quadricycle, rudimentary armour in the form of a shield. It was built by Charles E. Duryea to the order of Major R. P. Davidson, an instructor at the Northwestern Military Academy, then at Highland Park, Illinois, who became America's pioneer in the military application of motor vehicles. Apart from the original model, subsequently converted into a four-wheeler, Davidson was also responsible for two steam-engined gun-cars, built in 1900 in the Academy's workshop, which were successfully used for several years in training cadets, and a number of later military adaptations of motor vehicles.

In the meantime, in this country, Simms was engaged on the development of a fully armoured vehicle. The same report which referred to the appearance of the armed quadricycle, also mentioned that a drawing was exhibited at the Richmond show of a " war car " which Simms was building to the order of Vickers, Sons and Maxim, Ltd. The vehicle was not completed, however, until three years later, when, in April, 1902, it was shown at the Crystal Palace.[5] Moreover, it differed from the original drawing in the absence of the two gun turrets. Instead, its armament of two Maxim machine guns and one " pom-pom " automatic gun projected simply above the armoured hull, some contemporary photographs showing the guns with shields and others without.* The boat-shaped, open-top hull with rams fore and aft was built of 6mm Vickers armour, and was mounted on a four-wheeled chassis powered by a 16 h.p., four-cylinder Daimler engine. The drive was through a four-speed Daimler gearbox and in top gear the vehicle was stated to have a maximum speed of 9 m.p.h. Its weight, fully laden, was 5½ tons and it had steel tyred wheels, which restricted its operation to hard road surfaces and made later writers question its possible use. However, it was stated at the time as being intended mainly for coast defence and in this role its employment, along coastal roads, was feasible.

* Illustrated on page 368, April 11, 1902.

Contemporary reports also described the " war car " as an " invention " of Simms, but its conception certainly was not original. In fact, a very similar vehicle was proposed six years earlier by E. J. Pennington, an American inventor who flourished in the early days of British automobile engineering. When Pennington's ideas were first made public in 1896 they created something of a military sensation and not only were illustrations of his armoured car reproduced in the contemporary press,[6] but it was believed that he was actually building such vehicles.[7] In fact, Pennington's achievements fell far short of his publicity and already in 1897 led a French journal to remark " what a pity that the inventions of Mr. Pennington never exist but in the form of water colours."[8] Nevertheless, the erroneous belief persisted and Pennington has been credited with building the first British armoured car, even in the current guide to the Royal Armoured Corps Tank Museum.[9]

Pennington deserves some credit, however, for his ideas which anticipated Simms's design and in all probability strongly influenced the latter. There is certainly a striking resemblance between the " war car " and the vehicles on Pennington's drawings, and Simms seems to have followed them also in the use which he envisaged for his vehicle, as one of the drawings showed Pennington's armoured cars used for coast defence. What is more, Simms was connected for a time with the financial syndicate which had acquired the rights to Pennington's motor-car designs and acted as a consulting engineer when the former ostensibly was developing his designs for the syndicate. It is more than likely, therefore, that Simms was well acquainted with Pennington's ideas and derived his " war car " from them. If so, he made no significant contribution to the earlier conception and when the military authorities took no notice of the " war car "[10] neither he nor Vickers, Sons and Maxim, Ltd., showed any further interest in this type of vehicle.

After the failure of Simms's " war car "

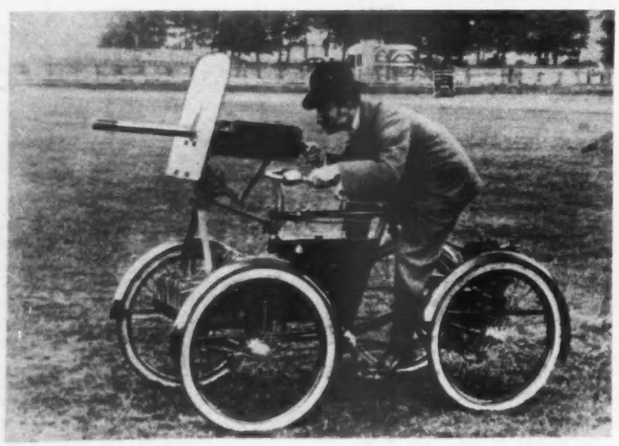

Fig. 1—F. R. Simms demonstrating his " motor scout," June, 1899

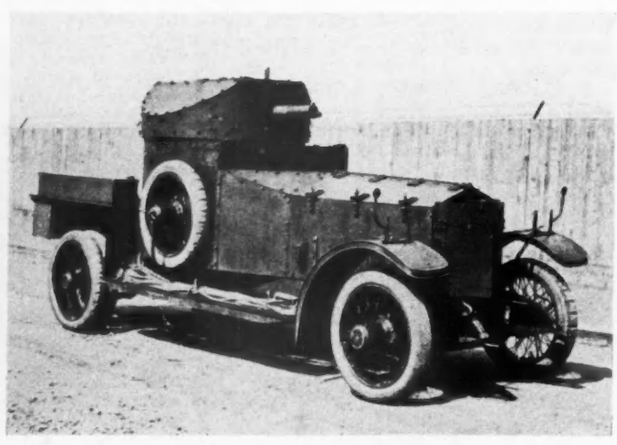

Fig. 2—Armoured car on Rolls-Royce " Silver Ghost " chassis

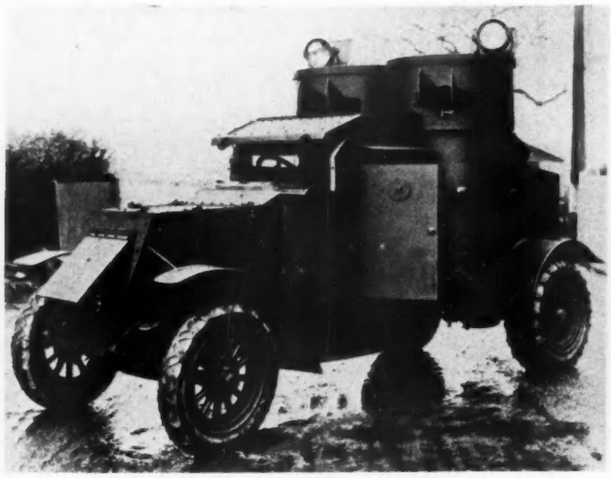

Fig. 3—Austin armoured car of 1917

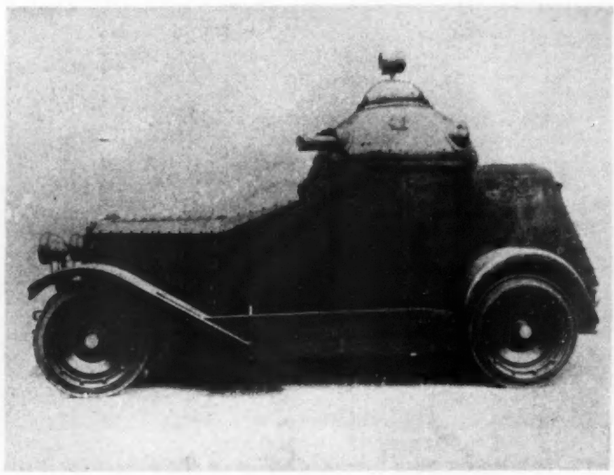

Fig. 4—Crossley armoured car of 1923

to arouse interest outside the technical press no further developments appeared in this country until 1914, but during the intervening twelve years armoured cars made significant progress on the Continent. In December, 1902, an armed, partially armoured car appeared the Salon de l'Automobile in Paris.[11] It was exhibited by the Société Charron, Girardot et Voigt and consisted of a touring car in which the rear seats had been replaced by an armoured circular tonneau in the centre of which was a pedestal-mounted Hotchkiss machine gun with shield. French military authorities tested it briefly in 1903, and although they did not adopt it the interest shown encouraged its builders to proceed with the development of a much improved model with a fully armoured body surmounted by a turret with all-round traverse. Empty, the new armoured car weighed 3·2 tons, and it was completed by the beginning of 1906. By then an armoured car had also appeared in Austria. It was designed by Paul Daimler in 1903 and built in 1904–5 by the Austro-Daimler Company of Viener-Neustadt. Like its French contemporary, it had a fully armoured body which was topped by a hemispherical machine gun turret, but its most significant design feature was that all four of its wheels were driven.

Both the Charron, Girardot et Voigt and the Austro-Daimler armoured cars were tried in their respective countries in 1906 and the latter performed particularly well due to its four-wheel drive, but the only sequel was an order placed by the Russian military authorities for ten vehicles of the former type. This constituted the first production order for armoured vehicles and nine vehicles were actually completed and delivered by the outbreak of the war in 1914. Other developments up till then amounted to the construction of a few more 4×2 armoured cars, such as the German Ehrhardt 50mm gun anti-balloon car of 1906 and the Italian armoured car built on a Fiat truck chassis at the Turin arsenal in 1912, or experiments with unarmoured gun-cars.

The rate of development cnanged radically after the outbreak of the 1914-18 war. Its opening, fluid stages offered considerable scope for the employment of motor-cars in military operations and this, in turn, led to the construction of armoured cars by several of the belligerents. The first of these, and notably the French and Belgian models, were of an improvised nature, having simple open-top armoured bodies mounted on Renault, Peugeot, Mors and Minerva car chassis and their armament projecting above the body, protected by shields. The first Rolls-Royce armoured cars built in September, 1914,[12] by the Royal Naval Air Service for its advanced units in France were also of this type, but in December, 1914, they were already followed by the first three vehicles of a much improved type, fully armoured and with an all-round traverse machine gun turret. Similar armoured cars were also built on Lanchester and Wolseley, as well as the Rolls-Royce Silver Ghost chassis. The Rolls-Royce model, which was the most typical of the second generation of war-time armoured cars as well as the most numerous, was armed with a 0·303in Vickers machine gun, and its armour was 0·3in thick ; with a crew of three men it weighed between 3·5 and 4 tons, but in spite of this the only modification to the chassis consisted of fitting special, heavy-duty leaf springs and its maximum road speed was still claimed to be 60 m.p.h. (Fig. 2).

However, by the time these improved armoured cars appeared in service in 1915, opportunities for their employment had virtually disappeared in Western Europe. The car chassis on which they were based confined them to road operation and when the fighting fronts stabilised this was not generally feasible. Attempts were made to devise ways of using armoured cars off the road, but this quickly led to another type of vehicle—the tank, which was introduced in 1916. The alternative course was to transfer armoured cars to other theatres of operations, where conditions were more favourable, as in Russia and in the Middle East. There they were able to show their value as highly mobile fighting vehicles, but their potentialities were only slowly recognised and their number remained small. For instance, the total number of armoured cars in the French Army at the end of the war amounted to only 272, of which 205 were built in 1918 on American White truck chassis. The number of British armoured cars was even smaller and of the widely used Rolls-Royce type only about 100 were built.

By far the largest number of armoured cars was used by the Russian Army. Its principal type was the British-built Austin of which 480 were built and, except for a small number diverted at the end of the production run to the British Army, delivered to Russia. The Austin represented an interesting departure from the contemporary practice in having two machine gun turrets, arranged side by side, and a second set of steering controls at the rear which, with a second driver in a crew of five, enabled it to operate relatively easily in reverse and obviated the need for turning around in difficult circumstances (Fig. 3).

The very small number of armoured cars built in Germany during the 1914–18 war also incorporated uncommon features : a Daimler and a Bussing four-wheeled car built in 1915 had all-wheel drive and the latter, like the Austin, had duplicated steering controls at the rear ; an Ehrhardt model of the same year, of which thirteen were built, had four-wheel steering as well as four-wheel drive. These advanced mechanical features were nullified, however, by the relatively heavy weight of 9 to 10 tons and the solid rubber tyres of the cars, whose overall performance consequently was inferior to that of the lighter armoured cars built elsewhere on pneumatically tyred car chassis, which were tied to a lesser extent to hard road surfaces.

The Germans persevered after the war with the development of heavy cars with four-wheel drive and in 1921 eighty-five such large 11-ton vehicles with solid rubber tyres were built by Ehrhardt, Daimler and Benz for security duties. In this country, on the other hand, attention concentrated on adaptations of available 4×2 car or truck chassis. These enjoyed the great advantage of lower cost and, at a time when fast tracked vehicles were still in their infancy, their limitations from the point of view of off-the-road performance were not considered too serious. Moreover, after 1918 the principal roles envisaged for British armoured cars were policing and medium distance road reconnaissance, and for both existing car or truck chassis were acceptable.

The first armoured car introduced after the war was very similar to the earlier Austins both in its twin turret layout and dual controls, but it was based on the Peerless truck chassis and so far as it had solid tyres, represented a retrograde development. The next model, based on 100 Rolls-Royce car chassis supplied in 1920, also represented no significant advance on the design evolved in 1914 by the Royal Naval Air Service. The only improvement was in detail modifications to make the chassis more suitable for military use and the car proved to have a remarkably long life for some were still in service twenty years later. Another new model, introduced in 1923 and used chiefly in India, adhered to the same general arrangement and was based on a Crossley truck-type chassis, with semi-solid tyres (Fig. 4).

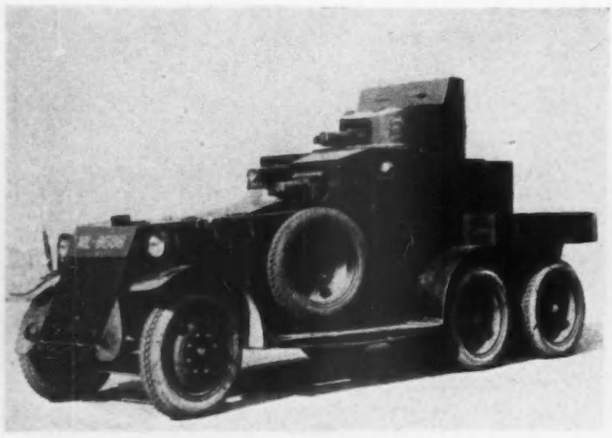

Fig. 5—Lanchester Mark I armoured car, armed with 0·5in and 0·303in machine guns

Fig. 6—The suspension of the Straussler was independent but both wheels of each pair carried the same load

Thus, for several years, British armoured cars continued to be based on conventional car or truck chassis and in consequence remained road-bound. The same applied to most other countries, but in France, where armoured cars were employed as part of the cavalry, attempts were already being made to improve their performance over soft ground. This took the form of replacing the rear wheels by short, continuous rubber tracks which increased the ground contact area and also increased its length in the direction of motion : the former reduced the pressure exerted by the vehicle on the ground surface while the latter improved traction, and together the two features produced a considerable improvement in off-the-road performance. The rubber track method was devised by A. Kégresse in Russia and as early as 1917 was applied to some of the Austin armoured cars used there. In France it was taken up in 1921 by the Citröen Company, and in 1923 the first sixteen armoured cars with the Citröen-Kégresse half-track chassis were ordered by the French Army. In 1925 a new order was placed for 100 armoured cars on an improved Citröen-Kégresse chassis, powered by a 15 CV Panhard engine instead of the original 10 CV Citröen model ; the actual order was placed with the Schneider Company, which had produced the armoured bodies for this and the earlier model, and the new type was consequently called the Schneider P.16. At the end of 1930 a further twelve vehicles of an improved Schneider-Kégresse type were ordered, but at this the development of the half-track armoured car virtually ceased in France. The principal reasons were the appearance of faster, fully-tracked armoured vehicles with more durable manganese steel tracks and progress in the design of wheeled vehicles, as well as the shortcomings of the rubber track, such as its vulnerability. Interest in the half-track chassis of the Kégresse type continued, however, particularly in the United States, where they were subsequently used as the basis of armoured personnel and general-purpose carriers, of which 41,170 were produced from 1941 to 1945.

In this country the application of the half-track chassis to armoured vehicles was confined to an experimental Burford-Kégresse machine gun carrier built around 1930. Otherwise, contemporary interest concentrated on the rigid six-wheeler whose development for transport purposes began in this country in 1924[13] and which was adapted to armoured car use from 1928 onwards. The first six-wheeled armoured car appears to have been built on a Guy medium lorry chassis, but at about the same time other 6×4 models were also built on Crossley medium and light lorry chassis and on a special Lanchester chassis (Fig. 5). Their performances were similar, with maximum speeds of 45 to 50 m.p.h., and in general considerably better than that of the earlier 4×2 vehicles, in spite of the fact that the Guy weighed about 9 tons, the heavier of the two Crossleys 8·28 tons and the Lanchester Mark I 7·3 tons. In addition to the four rear driving wheels, they also used larger-section tyres, which further reduced the pressure over the ground surface contact area and contributed as much to the overall improvement in performance as the second driven axle. But they were still handicapped off-the-road by the lack of drive to the front axle, the long engine bonnets which reduced drivers' visibility and the relatively low ground clearance, particularly in relation to the distance between the front and rear axles. Moreover, their suspensions with rigid axles were not suited to travelling over broken ground at any speed. It is not surprising, therefore, that in spite of their satisfactory road performance they gradually lost ground to light tanks whose development advanced considerably during the early 'thirties. It was only in 1937–1938 that the first steps were taken to develop new wheeled armoured vehicles, properly designed as such, for the British Army. By the outbreak of the war in 1939, the only new model in service was still based on a truck chassis—of the Morris 15-cwt light truck—and armoured cars had become a relatively unimportant item of British military equipment.

In the meantime, considerable progress had taken place on the Continent, in France, Austria and Germany, where, in spite of competition from fast tracked vehicles, armoured cars continued to be developed, mainly for reconnaissance purposes. In France, during the mid-'twenties, the Berliet Company had developed a chassis with three, evenly spaced, driven axles, and in 1927 brought out an experimental armoured car based on it. The vehicle proved unsatisfactory, mainly on account of its weight, and its modified 9-ton version was finally rejected by the French Army in 1931, but it foreshadowed the 6×6 designs which have come into prominence more recently. Another project, also in advance of its day, appeared in 1925 in Italy. It was based on the Pavesi wheeled tractor which had an articulated chassis with four large 64in diameter wheels, all driven, although still solid rubber-tyred. The articulated chassis allowed relative angular movement of the front and rear portions of the vehicle about a horizontal axis and also in a horizontal plane for steering ; it performed well over broken ground, but its development was limited to three experimental vehicles, although the Pavesi tractor was used subsequently for gun-towing by the Italian artillery. Only recently has there been a revival of military interest in articulated chassis vehicles with large diameter tyres—now pneumatic—as a result of their successful application in the earth-moving field.[14]

Of more immediate significance was an eight-wheeled armoured car developed between 1927 and 1929 by the German Daimler Benz Company. This model, the MTW, successfully combined several novel and highly desirable features, including eight-wheel drive, independent suspension, large 1060×200 tyres and chassisless body construction ; it also had dual—front and rear—driving controls and was amphibious, which was a particularly valuable characteristic for reconnaissance but which has not been successfully incorporated yet in armoured cars, in spite of a number of subsequent attempts. The development of the MTW was limited to two vehicles and it had no immediate issue, but it paved the way for two other 8×8 armoured cars introduced a few years later in Austria and Germany.

The Austrian model was the ADGZ built by Steyr-Daimler-Puch A.G., a large 7·95-ton vehicle with dual controls, built in prototype form in 1934 and then put into limited production amounting to fifty-two cars. Apart from being the first 8×8 model produced in any quantity, it was also the first armoured vehicle with a hydro-kinetic torque converter transmission, the Voith " Turbo-Getriebe " model JDL 5·4m2, which came a close second in time to the use of the Lysholm-Smith torque converter in Leyland buses and seven years ahead of the first torque converter installed in the U.S. M6 heavy tank of 1941. Two more promising designs were evolved in Austria by 1938, the rear-engined 6×6 ADKZ and the small, turretless 4×4 ADSK, but after the union with Germany the development of the Austro-Daimler armoured cars ceased.

The first two armoured cars supplied in quantity to the German Army between 1934 and 1936 were still based on commercial chassis, the light 4-ton Sd.Kfz.13 on the 4×2 Adler car chassis and the heavy 6-ton Sd.Kfz.231 on the Bussing-NAG ASP6 six-wheeled chassis. The former had an open-top armoured body, like the improvised armoured cars of 1914, but on the

Fig. 7—Daimler scout car : the bonnet is at the far end

Fig. 8—Much use was made of welding in the construction of the Guy armoured car

latter, in spite of its conventional front-engined truck layout, considerable attention had been paid for the first time to sloping all armour plates from the vertical to obtain improved protection. In 1937 came two new vehicles which became the standard German armoured cars throughout the 1939–45 war. The light model of the Sd.Kfz.221–223 series of 4·4 to 4·8 tons was based on the 4×4 Auto-Union Horsch 801 general-purpose rear-engined military chassis with independent twin coil spring suspension, each wheel being located by two unequal length radius arms and all four being steered. The heavy 8-ton model was based on a special eight-wheeled chassis developed by Bussing-NAG which incorporated a rear-mounted engine, eight-wheel drive with inter-wheel and inter-axle differentials, eight wheels steering from a duplicate set of front or rear controls, and independent suspension with each wheel located by two swinging links and front and rear pairs of wheels on each side being coupled by semi-elliptic leaf springs. It was a rather complicated vehicle but its cross-country performance proved very good, even under the extreme conditions encountered during the fighting in Russia, and it fully justified the effort put into the development of its multi-wheel drive and independent suspension.

Apart from the German Army, by 1939 the French had also reached the stage of having in service a specially designed armoured car. This was the Panhard 178, a rear-engined 4×4 vehicle of 7·85 tons, designed in 1933 and adopted in 1935 to replace earlier front-engined 4×2 models. In contrast, the Soviet Army adhered to armoured cars based on conventional 4×2 and 6×4 truck chassis—the 3-ton BA 20 and the 7-ton BA 10—well after 1939.

In this country the first clear break from contemporary car and truck practice was made by N. Straussler, who designed a rear-engined 4×4 armoured car with four-wheel steering, dual steering controls and independent suspension with swing axles and twin transverse leaf springs at front and rear (Fig. 6). The prototypes of this vehicle were built for Straussler Mechanization, Ltd., in Hungary, by the Manfred Weiss Company, in 1933, and one was supplied shortly afterwards to the Air Ministry, which resulted in improved vehicles of this type being ordered for the Royal Air Force, for security duties in the Middle East, and their subsequent production in this country by Alvis Mechanization, Ltd. The production was limited, however, to a few vehicles because of policy changes affecting the company, and this type of armoured car did not attract the attention which it might otherwise have done.

Of more direct consequence to British armoured car development was the design of a light 4×4 scout car initiated in 1937 by B.S.A., Ltd., and subsequently transferred to the Daimler Company, Ltd., which delivered the first vehicles in December, 1939 (Fig. 7). It was a 3·15-ton turretless vehicle with a six-cylinder, 60 b.h.p. Daimler engine located at the rear, the drive being taken through a fluid coupling and a five-speed preselective epicyclic gearbox to a central differential and then by parallel propeller shafts to bevel boxes at each wheel station.[15] The employment of a single central differential was not original or unique, as it had been used earlier in France on the Laffly 6×6 truck which served as the basis of the Laffly S.15 TOE armoured car of 1935, and later on the Italian Autoblinda 40 evolved at about the same time as the Daimler scout car. On the latter, however, the single central differential drive was used not only to eliminate the possibility of diagonal wheel spin, but full advantage was also taken of the parallel shaft drive to lower the centre of gravity of the vehicle and its overall height by locating the engine and the driver between the shafts. It had an independent suspension of the double wishbone type with double coil springs at all wheel stations and the original scout car was also provided with four-wheel steering, but this was abandoned on the Mark 1b and later models. Altogether, the Daimler scout car represented a major step forward in wheeled vehicle design and proved highly successful used for reconnaissance and liaison during the 1939–45 war, when 6626 were produced.

Another significant advance was represented by a rear-engined armoured car designed in 1938 by Guy Motors, Ltd., on the basis of their 4×4 Quad-Ant gun tractor (Fig. 8). Although it still used rigid axles, its four-wheel drive coupled with a relatively short wheelbase and large 10·50–20 tyres provided good cross-country performance and, for the first time in a British armoured vehicle, it incorporated an armoured body fabricated by welding. Welded armour had been used in Germany on a production basis from 1934 onwards,[16] and the Sd.Kfz.231, as well as the Austrian ADGZ armoured cars already had welded bodies, but the original order for the Guy I armoured car still specified riveted construction.[17] The change to welded fabrication was made on the initiative of Guy Motors, Ltd., who also evolved the necessary welding technique and tilting rotary manipulators, and resulted in a saving in weight, in the elimination of the accurate machining of plate edges hitherto necessary, and in a waterproof hull. In consequence, from 1939 every British wheeled armoured vehicle has been welded.

The appearance of the first Guy and Daimler cars was closely followed by a general revival of interest in armoured cars as a result of the mobile operations in France in 1940 and in the Libyan desert in 1940–41, and the urgent needs of home defence. The latter inspired several more improvised cars, the outstanding example being the " Beaverette " based on the Standard 14 h.p. car chassis, of which 2800 were built and whose design evolved from a simple open-top armoured superstructure of the Mark I and II to the fully enclosed and turreted Mark III and IV. Another adaptation of the same period and also classed as a light reconnaissance car, was based on the Humber " Super Snipe " car chassis : its production amounted to 3600 vehicles and its Mark III version graduated to four-wheel drive with independent transverse leaf-spring suspension at the front.[18] The principal components used on this vehicle were also used, rearranged to suit a rear engine location and a shorter wheelbase, on the Humber scout car,[19] whose production of 4300 supplemented that of the Daimler scout car.

As a result of the increased production the number of wheeled armoured vehicles grew considerably. Complete statistics have not been published yet, but it is believed that the total produced in this country between 1939 and 1945 was of the order of 30,000 and, in contrast to the 1914–18 war, exceeded that of tanks. In addition, 4746 armoured cars were produced in South Africa using American Marmon-Herrington and Ford chassis components and further supplies of armoured cars were obtained directly from the United States. The large numbers were a signal proof of the revival of interest in armoured cars, but in the long run their influence was to some extent detrimental to further development as a major part of the total was still based on adaptations of car or truck chassis. In consequence, many were well short of the existing possibilities in military wheeled vehicle design and their limited cross-country performance reflected adversely on armoured cars in general, particularly when military operations shifted in 1943 from the favourable conditions in North Africa to the more difficult terrain in Europe.

In the meantime, further developments had taken place in the design of armoured cars. After the completion of 101 the Guy armoured car was succeeded by the Humber, which was a very similar, short-wheelbase,

Fig. 9—Humber armoured car, Mark IV

Fig. 10—Mark I Daimler armoured car

6·55-ton, 4×4 model, but using a Humber "Super Snipe" engine and Commer chassis components, and for which Guy Motors continued to manufacture armoured bodies. The first was completed in February, 1941, and development progressed from the Mark I to the Mark IV (Fig. 9), but the only major change was an increase in the main armament from a 15mm Besa heavy machine gun to an American-made 37mm gun. A much bigger step forward was represented by the appearance of the Daimler armoured car, whose development began in 1939 and production eventually mounted to a total of 2694. Mechanically it was, in essence, a scaled-up version of the Daimler scout car, but apart from its greater weight of 6·8 tons (later 7·7) it had a two-man turret with a 40mm, 2-pounder gun and a coaxial 7·92mm Besa machine gun (Fig. 10). It followed Continental practice in having a duplicate set of driving controls at the rear of the fighting compartment and, like the scout car, originally it had four-wheel steering, but the latter was abandoned as was the provision of inter-wheel differentials on each side.[20] Its other features included a total vertical movement of each wheel of as much as 16in and the use of Girling disc brakes, which were a novelty not only in armoured car design, but in wheeled vehicles in general.

Apart from its mechanical features, the Daimler also represented a considerable advance in armoured car armament. Most of the early models were armed with rifle-calibre machine guns only, although the French also used short-barrelled 37mm guns and a Russian armoured car of 1917, built on an American Garford truck chassis, already carried a 76·2mm gun. The Lanchester of 1930 was the first to be fitted with a 0·5in, as well as 0·303in, Vickers machine gun which brought its armament up to the contemporary light tank standard and by the mid-'thirties Austrian, German and Swedish armoured cars carried 20mm automatic cannon in addition to machine guns. At this further increases stopped for a time, except for the French Panhard 178 which had a 25mm gun, and the Soviet BA10 which had a 45mm gun. During the 1939–45 war, however, further increases took place in armament, particularly under the influence of the operations in Libya, and attempts were made to revive the use of armoured cars as fighting, as well as reconnaissance, vehicles and make them compete with tanks.

The latter consideration led to the construction in 1942 of the 11-ton A.E.C. I armoured car, mounting the turret of the "Valentine" infantry tank. Mechanically, this model was based on the components of the A.E.C. "Matador" 4×4 tractor and in principle represented no advance on the earlier Guy and Humber models, while its original armament was the same as that of the Daimler. But its maximum armour thickness had increased to 32mm, as against 14mm on the Daimler, and its armament went up to a 57mm six-pounder on the A.E.C. II and to a medium velocity 75mm gun on the A.E.C. III, which weighed 12·7 tons (Fig. 11). Another heavy armoured car, and the last to be developed during the war, was the "Coventry," built by the Rootes Group. In many ways the "Coventry" I resembled the Daimler but was larger, weighed 11·5 tons, and reverted to the more conventional transmission layout, with the drive from the transfer box being taken by single propeller shafts to front and rear differentials; on the "Coventry" II the main armament was increased from the 40mm gun to a 75mm, but neither model was produced beyond a few experimental vehicles.

The medium velocity 75mm guns of the A.E.C. III and the "Coventry" II were comparable to the armament of some contemporary medium tanks, but further attempts to compete with the latter would have entailed much heavier guns and vehicles, so much heavier as to be impracticable in a wheeled form. Similarly, attempts to increase armour protection entailed further increases in vehicle weight and as complete immunity to direct hits by large-calibre projectiles could not be ensured, armour protection has been limited to between 8mm and 15mm, generally sufficient against small arms and shell fragments.

The experience gained in Libya in 1940–41, which exerted such an influence on the development of British armoured cars, also contributed to the revival of armoured car development in the United States. None had been built there from 1934 to 1941 and in 1942 production amounted to a mere 191 vehicles, but by the end of the war the total rose to 16,438. Initially, the development tended to relatively heavy types, such as the

Fig. 11—A.E.C. Mark III fighting vehicle armed with a 75mm gun

Fig. 12—"Ferret" Mark II scout car

T13, an 11·2-ton, eight-wheeled vehicle with the six rear wheels chain-driven and steering confined to the unpowered front axle; the T17E1, a 12-ton 4×4 with rigid axles, and the T18, a 23·6-ton 8×8, also with rigid axles and with armour up to 50mm thick. The T17E1 was produced in quantity for the British Army as the "Staghound" armoured car, but American development moved in the opposite direction to the British, towards much lighter vehicles, and the model eventually adopted in 1943 by the U.S. Army was the 7·7-ton 6×6 M8 (originally T22E2). Apart from its weight and 19mm maximum armour thickness, the M8 was similar to the other American armoured cars in having its engine at the rear and using rigid axles, which were unevenly spaced in the conventional truck manner. However, by the end of the war, a much more advanced 6×6 T28 armoured car was evolved by the Chevrolet Division of the General Motors Corporation. This had evenly spaced axles, independent suspension with swing arms and coil springs, servo-assisted steering on the front four wheels and weighed only 6·8 tons. Its cross-country performance was greatly superior to that of the M8, which it was intended to replace, but although it was officially accepted in March, 1945, under the M38 designation, it was never made in any quantity, as shortly afterwards the U.S. Army again decided to abandon armoured cars, partly because of the progress made with tracked armoured vehicles and partly because of the wheeled armoured vehicles hitherto used, none of which was sufficiently advanced from the point of view of cross-country operation.

The post-war American views were not shared in this country, nor in France, and both countries proceeded to develop new armoured cars. In this country the Daimler Company has produced an improved version of the Daimler scout car, the 4-ton "Ferret," with lengthened 90in wheelbase, which enables it to travel faster over uneven ground (Fig. 12), and with a Rolls-Royce B.60 six-cylinder engine of 116 b.h.p. The successor to the Daimler armoured car is the "Saladin," manufactured by Alvis, Ltd., and closely related to the Alvis "Saracen" armoured personnel carrier, although its prototypes were actually built in 1953 by Crossley Motors, Ltd. The "Saladin" (Fig. 13) is a 10·5-ton 6×6 armoured car powered by an in-line eight-cylinder B.80 engine of 160 b.h.p., which carries a crew of three and an armament of a turret-mounted medium-velocity 76·2mm gun and coaxial Browning machine gun. Its mechanical layout, with a single central differential and parallel propeller shafts, is basically similar to that of the Daimler, except for two additional wheel stations and the use of torsion bars instead of coil springs; on the other hand, its chassis dimensions and 12.00–20 tyres are very similar to those of the American M38, as is the use of two steered front axles with servo-assistance.

In France an unusual eight-wheeled armoured car has been produced by the Panhard Company, in which the heavily spudded four centre wheels are normally raised off the ground for road operation. This design was derived from an experimental Panhard 201 of 1940, and the use of retractable centre wheels can be traced back even further, to the Gendron-Poniatowski 6×6 armoured car built in 1935 by the Société d'Outillage Mécanique et d'Usinage d'Artillerie (S.O.M.U.A.). Like the latter, the present Panhard E.B.R. has an engine located amidships, under the floor, the engine being an air-cooled, horizontally opposed, twelve-cylinder only 9in high overall and developing 200 b.h.p. There are two sets of driving controls and the normal crew of four men includes two drivers, while the other two crew members occupy the turret which mounts a 75mm gun and a coaxial machine gun. Fully laden the E.B.R. weighs 13·5 tons and its maximum road speed is quoted as 60 m.p.h.

In addition to its road speed, the Panhard E.B.R., like the "Saladin," is also capable of impressive performance off the road and under many conditions it can successfully compete with tracked vehicles. On soft ground armoured cars suffer, of course, from the basic disadvantage that the length of their surface contact area is short in the direction of motion which limits their traction, but, except for extreme conditions, this need not handicap them unduly in relation to tracked vehicles provided the weight of the vehicle is moderate. Low weight is also important from the point of view of flotation, but the latter presents a somewhat easier problem than traction as there is more scope for increasing tyre width—and thus securing adequate surface contact area—than there is for increasing tyre diameter to obtain longer contact area. Nevertheless, light weight is still very desirable, as it is from the point of view of overall mobility.

In the light of the above points, the steady increase in the weight of armoured cars from about 3 to 4 tons to more than 10 tons for typical models is unfortunate, and is no longer entirely justifiable on the grounds of armament because light weight is no longer incompatible with the installation of powerful weapons, such as large-calibre recoilless guns or short-range guided missiles. Other developments have been largely beneficial, but none more so than the move away from adaptations of car or truck chassis to armoured cars designed from the point of view of cross-country as well as road operation. The former method remains unassailable on economic grounds, but without breaking away from it armoured cars could not have secured a place for themselves beyond the narrow confines of road operation. As it is, the gradual adoption of all-wheel drive, large low-pressure tyres and independent suspensions with large wheel movement have given armoured cars good cross-country performance in addition to their road performance. The combination of the two frequently gives them a considerable advantage over tracked vehicles and makes them eminently suitable for many types of mobile military operations. It is not surprising, therefore, that the development of armoured cars is continuing and the recent conversion of a number of units of the Royal Armoured Corps from tanks to armoured cars suggests that their importance is, in fact, increasing.

Fig. 13—The "Saladin" armoured car carries a 76·2mm gun: notice the projectors to lay out a protective smoke screen

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ALUMINIUM CONVEYOR FOR IRON OXIDE.—We are informed that an iron oxide conveyor built of aluminium alloys has been installed at the Rochdale Road Gasworks, Manchester. The conveyor is 250ft in length and consists of a 24in wide belt, chutes and walkway suspended from the roof trusses. The Northern Aluminium Company, Ltd., supplied the plate and sections, which were to specification H30 and fully heat treated.

Dockside Cargo Crane

A new design of dockside crane, which has been developed by Stothert and Pitt, Ltd., of Bath, can be supplied with alternative jibs to lift 5 tons at 80ft radius or 6 tons at 70ft radius. In this crane the conventional braced portal structure has been replaced by four main tubular legs of large diameter, and a hydraulic ram is used for luffing. It is built in accordance with the requirements of British Standard Specification 2452 : 1954, *and combines a reduced overall weight with simplicity in operation and ease of maintenance.*

THE prototype model of a new design of portal crane developed by Stothert and Pitt, Ltd., of Bath, for dockside cargo handling duties has successfully completed its trials and was recently demonstrated at the firm's works. This crane is designed to lift up to 5 tons at 80ft radius, and it can be fitted with an alternative jib to handle 6 tons at 70ft radius. The leading particulars of the machine with its two forms of jibs are given in the table below, and its general design can be seen in the photographs and drawing we reproduce on this page. The conventional braced portal structure has been replaced in the new crane by an assembly of four large diameter tubular members of welded plate construction. These main tubular members are locked together in a ring at the top and at the upper part of the vertical leg sections by a cruciform joint provided by projecting box sections. All the main units of the crane structure are connected together by high-tensile bolts with the use of torque wrenches, thus providing a crane which can be dismantled and re-erected on another site with relative ease if so required.

The use of tubular members in the main structure has enabled maximum weight/strength and weight/stiffness ratios to be achieved, whilst the area of exposed surfaces subject to corrosion has been kept to a minimum. In this connection it is the makers' claim that the area of steelwork which requires painting is about half that of the conventional portal crane whilst the large smooth corner-free areas further reduce the costs of maintenance painting. This fact can be appreciated when the new crane shown in our illustration is compared with the conventional portal crane at its side. Each leg is fabricated as a complete unit and when the main structure has been assembled on site the lower, vertical, parts of the legs are each filled with some 4 tons of concrete ballast. The prototype crane is mounted on 13ft 6in gauge rails, but it is stated that a crane made for 15ft gauge and over would not require ballast in the legs.

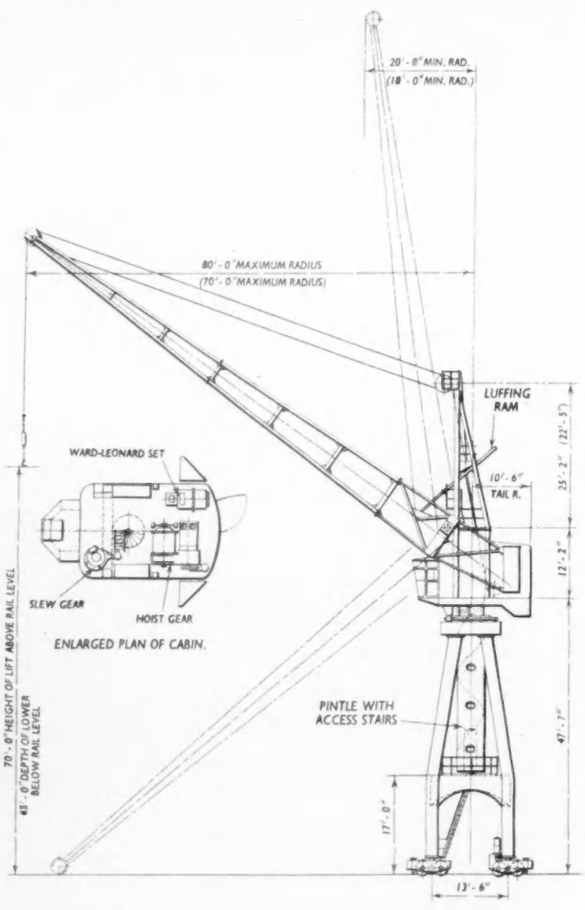
A long pintle tube attached to the underside of the rotating superstructure is fitted, at the upper end, with three adjustable rollers which rotate inside a segmental roller path bolted to the truck top. On the outside of the path ring are machined the spur teeth with which the slewing pinion engages. At its lower end the pintle tube is supported by a roller thrust and journal bearing immersed in oil on the platform, which is provided at the point where the legs are coupled together.

The machinery house, carried on a rigid deck, is a steel-framed structure enclosed by walls which are made of translucent resin-bonded glass fibre and provide a good level of uniform natural lighting within. The

General Particulars of Dockside Crane

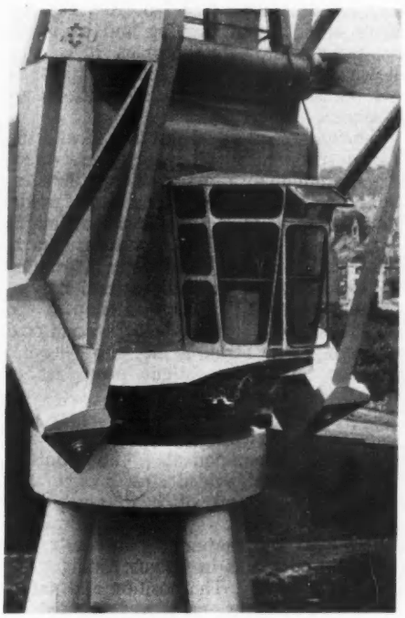
	5-ton model	6-ton model
Maximum load	5 tons	6 tons
Radius	20ft min. / 80ft max.	18ft min. / 70ft max.
Jib centres	90ft	78ft
Tail and clearance radius	10ft 6in	10ft 6in
Rail centres	13ft 6in	13ft 6in
Height of cab floor	47ft 10in	47ft 10in
Height of jib foot axle	59ft 9in	59ft 9in
Height of apex pulley	84ft 11in	82ft 3in
Diameter of rail wheels	2ft 3in	2ft 3in
Total weight	82 tons + 12 tons concrete at site	82 tons + 12 tons concrete at site
Maximum wheel load	22 tons	22 tons
Height of C.G. above rails	About 32ft	About 32ft
Hoisting speed maximum 60 h.p. motor	0 to 5 tons, 425 to 144ft/min	0 to 6 tons, 425 to 120ft/min
Hoisting speed maximum 75 h.p. motor	0 to 5 tons, 425 to 180ft/min	0 to 6 tons, 425 to 150ft/min
Slewing speed	1¼ r.p.m.	1¼ r.p.m.
Luffing speed	0 to 160ft/min	0 to 160ft/min
Travelling speed	50ft/min	50ft/min

Portal crane available with alternative jibs for handling 5 tons at 80ft or 6 tons at 70ft radius



Arrangement of 5-ton capacity cargo crane—dimensions for 6-ton crane shown in brackets

house is particularly roomy, and in it the machinery is well spaced and arranged to give easy access to all parts for inspection and maintenance purposes. A wall crane which can be swung out through large jack-knife doors at the rear of the house is of sufficient capacity to handle any of the machinery units—the heaviest of which weighs about 30 cwt. The driver's cabin, built out in front of the machinery house, is also clad with resin-bonded glass fibre and it has large windows giving a clear, unobstructed view of the jib and load in all positions, as can be seen in our illustration below. Simple joystick controls are situated conveniently to hand by a comfortable adjustable seat which is provided for the crane driver. Access to the driver's cabin is obtained by a step ladder to the pintle platform level, where



Driver's cabin in front of the resin-bonded glass fibre machinery house of the crane

there is a sliding door leading into the pintle tube, up the centre of which a spiral staircase leads into the machinery house, where a door gives admission to the cabin. Ladders in the machinery house give access through a trap door in the roof of the luffing ram and the apex pulley. No jib ladder is provided as access to the top sheave is effected, when necessary, by lowering the jib head to the ground, as shown in the drawing.

The straight jib, of welded tubular construction, comprises three sections bolted together, and it is so designed that all its main members share equally the maximum loading and stress. It is balanced in all positions and has only one pulley spindle at the head, so that unnecessary bending stresses are eliminated. A cross axle fitted as an integral part in the jib turns in split trunnion bearings bolted to the crane superstructure. Triangular-shaped balance weights used for the jib are designed to ensure that the maximum moment is obtained with the smallest possible weight and the minimum tail radius. In the Toplis level luffing arrangement used the rope angles have been arranged to render unnecessary the fitting of a back pulley at the superstructure apex. A simple pivoted jib locking latch fitted on the superstructure can be engaged when the crane is to be taken out of service for an appreciable period.

A single central double-acting hydraulic ram between the crane superstructure and the jib is used for luffing purposes, and through it luffing can be effected at any speed up to 160ft per minute. The hydraulic system is designed to give smooth acceleration and deceleration of the jib in all positions, and a cushioning arrangement which is incorporated eliminates jerky motions, whilst risk of overloading the gear is eliminated.

The hoist winch is driven by either a 60 h.p. or a 75 h.p. motor with Ward Leonard control, and power is transmitted to the barrel through double helical and spur gearing. In the control an exciter, energised by the current in the armature loop circuit, simultaneously controls the winch motor field and the generator field. With this equipment variable hoisting and lowering speeds under driver control are provided, and the hoisting speeds with the alternative motors available can be seen in the table. Light loads can be hoisted at three times the speed of the maximum load, and intermediate loads are hoisted at corresponding speeds, without need for the use of discriminating relays in the equipment. A similar characteristic is available when lowering, i.e. as the load is increased the maximum speed is decreased.

The slewing pinion meshes with a segmental spur gear ring bolted to the top of the main truck structure, and this ring is an integral part of the slewing roller path. The pinion is driven by a 15 h.p. slip ring motor through a fluid coupling and spur gearing, giving a slewing speed of $1\frac{1}{4}$ r.p.m. This fluid coupling, in addition to ensuring a smooth and even drive, protects the motor and gearing against overloading and shock loads. The action of a thruster controller brake fitted in the hoist drive can be intensified by a pedal-operated hydraulic gear which incorporates a limiting device to prevent excessive overloading. By this arrangement the driver is given a sensitive but limited control for arresting the slewing motion and at the same time there is provided an automatic brake capable of stopping and holding the revolving part of the crane independently of the driver.

Each of the four legs of the crane is mounted on a two-wheeled bogie and the bogies are attached to the legs through swivelling and rocking gear which minimises the effect of cross racking and enables curves to be negotiated. An equalising jack with a protected screw is fitted on each bogie. Two of the bogies are driven by 6 h.p. squirrel cage motors through fluid couplings and worm and spur gearing, giving the crane a travelling speed of 50ft per minute. These powered bogies have automatic solenoid-operated brakes and the others have hand-operated safety locking devices. When a crane of this design is required for service on rail tracks of 20ft gauge or over, the makers state that the number of legs can be reduced to three.

In addition to the attention which has been paid in designing the crane for ease of control and simplicity of erection, particular attention has been given to reducing maintenance to a minimum. All the high and medium speed shafts are carried on grease-packed and sealed ball or roller bearings which rarely require attention. A majority of other bearings are lined with graphite impregnated " Ferobestos " and only require regreasing about once a year, mainly to prevent rusting of the shafts. If required, cranes of this design can be adapted for occasional grabbing duties.

Commonwealth Conference on Standards

THE fourth Commonwealth Standards Conference will be held in Ottawa from August 24 to September 4 next, and the countries to be represented include, in addition to Canada and the United Kingdom, Australia, New Zealand, South Africa, Pakistan and India, whilst an observer will attend from the Institute for Research and Standards in Dublin. There will be a general session and three main technical sessions concerned with steel, air receivers and cranes.

Among the subjects to be considered at the general session is certification marking, with particular reference to the principles of quality control to be included in standards and the schemes of supervision related to certification marks. Discussion of the problems of inch and metric dimensions in standards will be particularly concerned with India's position *vis-à-vis* the rest of the Commonwealth, with conversion between the inch and metric systems, and the showing of equivalents in Commonwealth standards.

Progress reports on the technical subjects considered at the last Commonwealth conference at Delhi in 1957 (safety of domestic electrical appliances, cables and electrical equipment of machine tools) will be presented and future work in these fields as well as for new projects will be planned. In this latter connection, separate preliminary talks on asbestos fibres and on gas cylinders have already been arranged.

In the technical session on steel, alignment of Commonwealth standards for hot rolled sections, on which both India and the United Kingdom have put forward proposals, will be the main subject for consideration. Discussion will also take place on standards for high strength torque bolts, cold formed light gauge construction and tubular steel construction, and on the co-ordination and rationalisation of carbon alloy and special steels.

At the session on air receivers the aim will be to achieve some measure of unification not only of the standards in the various Commonwealth countries, but also of requirements for inspection and acceptance—an achievement which would considerably facilitate export trade. The amendment of the various statutory rules and regulations at present controlling these requirements would, it is hoped, follow from agreement at the session. Three main types of air receiver are to be considered : welded steel; pressure containers for paint ; and solid drawn steel. Five British Standards have been tabled by B.S.I. for use as a basis for the discussions.

Methods of expressing load ratings and the alignment of stability requirements, together with methods of calculating stresses, will be the principal topics at the session on cranes. The draft revision of B.S. 2573 " Report on permissible stresses in crane structures " will be tabled for reference at this session. The regulations in Commonwealth countries for the use, safety requirements and construction of cranes will also be reviewed.

Code of Practice

GUIDE TO THE LOADING OF TRANSFORMERS TO B.S. 171

Code 1010 : 1959. Price 7s. 6d. This new Code of Practice contains thirty-one pages of guidance on the loading of oil-immersed transformers to B.S. 171 (" Power Transformers ") with Class A insulation, and is based on their thermal characteristics and fittings. C.P. 1010 therefore supersedes earlier recommendations and is applicable to oil-immersed transformers supplied to past and present issues of B.S. 171. It sets out a list of basic data which include, as a basis for the recommendations, four categories of daily operating conditions associated with the permissible maximum temperature of the windings. The information is given in a series of tables and their use is illustrated by examples. One of the examples shows how a user with a transformer in service can permit the transformer to carry a load above its rated kilovolt-amperes without reducing its potential life. Another example shows how a system planner with anticipated average and peak daily loading conditions can choose a transformer with the most appropriate kilovolt-ampere rating.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ECONOMY AND NOISE OF HELICOPTERS

SIR,—The need, suggested in your leader, to select a site for a heliport near the centre of London, will not arise until there is evidence that helicopters can be reasonably economical and reasonably silent. The din caused by helicopters hovering over the West End in recent months has been a serious interference with office work, rendering conversation and dictation impossible.

A tube train from the centre of London right into the airport terminal building is the only thing which can deal adequately with the large numbers of passengers who will travel by air.

L. B. SHUFFREY

Reform Club,
London,
August 13, 1959.

[Are helicopters really as objectionably noisy as our correspondent suggests ? In our view they do not compare in that respect with modern motor-cycles!—ED., THE E.]

Book Reviews

The Nimonic Alloys. By W. BETTERIDGE. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 80s.

KNOWLEDGE gained from works practices and in laboratories has been combined in this book, in a concise and logical manner, which will appeal to engineers. It will also prove to be very valuable to scientists whose work requires them to study the behaviour of materials at elevated temperatures.

In the critical wartime period and through the succeeding years the author was extraordinarily well placed to become expert in this subject. He was the leader of a research team in the laboratories of the Mond Nickel Company and he was working in close association with Henry Wiggin and Co. During that long period it was these concerns which were leading the metallurgical world in the practical development of that whole range of high-temperature alloys which may be said to have grown from the 80/20 Nickel Chromium alloy, to become the famous " Nimonic " series of alloys which are now used in almost all gas turbines.

This handy sized volume, with 332 clearly printed pages which are suitably illustrated, is concluded with a list of 144 references, an author index, and a subject index. It is a real achievement to have packed so much first-hand information, much of which is now essential to many students, research workers and designers, into an octavo book which is slim enough to take with one to read on a train journey.

According to Whittle, who pioneered the development of gas turbines for aircraft propulsion, their ultimate success was dependent on the special metallic materials which were developed to withstand the high centrifugal stresses at the high working temperatures, which are needed for reasonable thermal efficiency. A useful impression of the high-temperature strengths of these new alloys may be gained by noting the difficulty encountered in flash-butt welding them. Even after using appropriately high secondary voltage, on account of their great electrical and thermal resistance, much greater upset pressures are required than with steels ; indeed Nimonic 90 often needs upset pressures of 30 tons per square inch, although some successful welds have been made at lower pressures.

The author generously acknowledges the help of his fellow workers by stating that the chapters on " Analysis," " Hot and Cold Working," " Joining," " Casting," and " Inspection " were largely the work of six of his colleagues whom he names ; rightly so because his book has gained added authority from these contributions from their specialised knowledge.

It is generally accepted that the basis of a good high-temperature alloy, which is resistant to creep, should be a relatively complex solid solution containing a number of different metals having the widest possible dissimilarity in atomic sizes. The author therefore indicates by a series of phase diagrams what may be expected in the constitution of this very complex family of alloys. Starting with the relatively simple binary alloy systems of Nickel-Chromium and Nickel-Aluminium he passes on to such complex alloys as those containing Nickel-Cobalt–Chromium–Titanium–Aluminium–Iron–Molybdenum, and significant quantities of carbon and nitrogen. The mind boggles at the number of variables which may be important and one's admiration grows for those who manage to produce regular supplies of the desired composition and heat treatment.

Unfortunately it is not possible to show by means of an understandable phase diagram what the cumulative effect of so many variables will be. The author's connection with works practices must therefore have been quite as essential as any theories when he was writing the latter part of the book. There one finds mechanical properties at normal and at elevated temperatures, corrosion resistance, joining, castings, machining and finishing, and inspection methods ; all of which are matters of very great practical importance to the user of these new materials.

Many readers will find the last chapter the most interesting of all for in it the author outlines his ideas of the ways in which these alloys may find use in future engineering.

Metal Fatigue. Edited by J. A. POPE. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 70s.

FACTS of special importance to engineers have been gathered and arranged in an orderly manner in the 375 pages of this clearly printed and well illustrated book. Practical experience with many failures in which fatigue or corrosion fatigue have played a major part has forced all modern designers, maintenance engineers and teachers to give attention to this problem. There have been many symposia at which engineers and metallurgists have made available their facets of the truth, and professors in other countries have set out to write books on this same subject. This contribution from Professor J. A. Pope will stand comparison with any of them in its authority and usefulness. In 1955 at the author's Engineering Department in Nottingham University a week's residential course on the fatigue of metals was held, which 150 members from industry attended. The twenty chapters of this book are derived from the lectures given at that course in which the author had the help of fifteen British experts.

Part 1 of the book deals with the fundamentals of fatigue. Here at last corrosion fatigue, fretting and temperature effects are dealt with systematically and this part of the book will be essential reading for many engineering students in the coming years. Many of the early laboratory experiments on the fatigue of metals failed to fit in with practical experience because the research workers of those days overlooked the effects of corrosion, fretting and high and low temperature effects, which it is now known play a highly significant part in most of the fatigue fractures which occur in service.

The eight chapters of Part 2 deal with the fatigue properties of high temperature alloys, aluminium alloys, cast iron, brasses, bronzes and bearing metals and also of welds. Moreover they cover the problems of fatigue loads and their effect on aircraft structures. This recalls the great work done in probing the Comet aeroplane under conditions of repeated stressing, which attempted to simulate those which might be encountered in taxying and flight. One whole lecture was devoted to the fatigue properties of joints.

The third part of this book contains four chapters devoted to the fatigue testing of engineering components ; those on the fatigue testing of welded structures, of aircraft structures and of bearings will be especially valuable. Statistically minded readers will find the chapter on the reproducibility of results in fatigue testing to be worth their study. The position and nature of fatigue failures may be regarded as normally reproducible, but the endurances often vary much more than would be expected. Unfortunately for engineers the prediction of minimum life depends upon a detailed knowledge of the distribution of scatter, which is virtually inaccessible at present. Despite that pessimistic view one may say that the more this book is studied the more valuable it appears. It deserves a better index ; the five pages of indiscriminately mixed subject and author index provided is not easy to use and appears to be inadequate. For example, it seems surprising to find the name of Professor Haigh missing from the index, bearing in mind the great contribution he made to our understanding of corrosion fatigue forty years ago in this country.

Each of the twenty chapters of this book commences with a synopsis and each concludes with a short list of references. The first five chapters are the personal contribution of the editor, a third of the lectures were given by members of Nottingham University, and the remaining lectures were given by experts invited by the organising committee from industry, research associations and Government departments. Every engineering designer should try to master Part 1 of this book, which will be of value to research workers new to the very complex problems of metal fatigue. Professor Pope and his co-authors are to be congratulated on having produced a really useful book.

Tunnel Engineering. By ROLT HAMMOND, A.C.G.I., A.M.I.C.E. Heywood and Co., Ltd., Carlton House, Great Queen Street, London, W.C.2. Price 55s.

THE author points out that there are few up-to-date books about tunnelling. Articles in the technical press and papers to the learned societies—the only sources of information—generally refer to one specific project, and are not, therefore, he considers, convenient as a reference to contemporary practice. This volume is, therefore, a review, largely culled from the two sources mentioned, of the problems and practices of to-day in soft and rock tunnelling.

The general manner of presentation, familiar to readers of Mr. Rolt Hammond's earlier volumes, is again to be found in *Tunnel Engineering*. A pleasing feature is the easily readable style of the text. But against this must be set some illogicality in the arrangement of the chapter headings and subject matter, which do not conform to the order or relative importance of exposition which an engineer well versed in tunnelling would follow. Again, some topics, for instance, the "trench tunnel" technique, are not covered. But in spite of this, a great variety of modern devices in tunnel driving, lining and shaft sinking are described in this broad survey of present-day practice.

Modern Engineering Workshop Practice. Editorial Consultant, W. A. TUPLIN, D.Sc., M.I.Mech.E. Odhams Press, Ltd., 67–68, Long Acre, London, W.C.2. Price £9 5s.

THIS work comprises three volumes of text and a wallet of charts, and it is designed to provide a comprehensive reference on the latest methods and equipment used in engineering workshops. Some twenty-four contributors under the editorial consultant, Dr. Tuplin, have been responsible for the preparation of the subject matter.

In the first volume the subjects dealt with include bench work, drawing, mathematics, materials, measurement and lathe practice. The second volume covers welding, soldering, brazing, jigs and fixtures, toolmaking, machine tools, gear cutting and foundry work. The third volume deals with forging, heat-treatment, sheet metalwork, plating, power supply, plant installation, and time and motion study. In the wallet forming the fourth volume of the set there are forty-four sheets of tables and standard data allied to the subject matter in the volumes of text.

Each subject is dealt with in a clear concise way and the text is well illustrated with photographs and drawings. These volumes should provide a useful source of reference on the many aspects of modern workshop practice for students and apprentices.

The History of Wagons-Lits, 1875–1955. By GEORGE BEHREND. Modern Transport Publishing Company, Ltd., Russell Court, 3–16, Woburn Place, London, W.C.1. Price 3s. 6d.

COMBINING a detailed narrative with a lively assortment of anecdotes, the author has achieved an historical record which may be read with pleasure by all who have felt the fascination of the sonorously entitled Compagnie Internationale des Wagons-Lits et des Grands Express Européens. The title did not come into being until 1883, when the company first ran a complete train of its own rolling stock. This was the Express d'Orient, a name soon anglicised and universally familiar as Orient Express. The beginnings and development of many other famous services are related, some still well known and others almost forgotten, such as the Continental Club Trains of that unimaginable era when, as we are told, "only five minutes elapsed between the trains' arrivals and the paddle steamer's departure"; and when, two Wagons-Lits conductors at Dover "fought for the right of *habeas corpus*" over a single passenger arriving from Paris. In the 1914–18 war the company lost its rolling stock and assets in Germany and sold its Russian-gauge vehicles to the Soviets. The inter-war years were a period of intense activity both in and outside Europe, but the second world war brought grievous losses and after it only three trains composed of Wagons-Lits stock throughout were resumed in Europe as compared with twenty-one running in 1939. One of them was the Paris–Marseilles–Ventimiglia express, long known as the Blue Train, although not officially named until 1949. On the other hand the number of vehicles operated is increasing and the company is concerned in buffet car arrangements in seven Trans-Europe Express services. The author has collected some fascinating historical illustrations and also gives layout diagrams and photographs of modern stock. The reader with a moderate knowledge of European railway geography may find himself puzzled at times in following the evolution of the more complex facilities, and a map of the principal routes traversed or individual sketch maps of selected services and their ramifications would have been helpful in this respect.

Die Berechnung der Zylinderschalen. By A. AAS-JAKOBSEN. Berlin–Göttingen–Heidelberg: Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price DM.22·50.

THE calculation of shell structures is carried out on the two assumptions of an ideal elastic material, perfectly obeying Hooke's law, and of simplified boundary conditions which enable the basic differential equations to be integrated. It can be shown that such "model shells" give results in sufficient agreement with actual structures. In treating the cases of barrel vaults and tanks, the author develops in detail the underlying mathematical ideas, but always seeks to arrive at simple formulæ and tabulated results in order to facilitate the arithmetical working of problems.

Books Received

Principles of Electrolysis. By C. W. Davies. The Royal Institute of Chemistry, 30, Russell Square, London, W.C.1. Price 3s. 6d.

A Manual of Good Housekeeping and Safety. Hot Dip Galvanizers' Association, 34, Berkeley Square, London, W.1. Price 25s.

Principles of Oxidation and Reduction. By A. G. Sharpe. The Royal Institute of Chemistry, 30, Russell Square, London, W.C.1. Price 3s. 6d.

Basic Geology for Science and Engineering. By E. C. Dapples. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 76s.

Properties of Matter. Third Edition. By F. C. Champion and N. Davy. Blackie and Son, Ltd., 17, Stanhope Street, Glasgow, C.4. Price 40s.

Baustatik Theorie und Beispiele. By K. Hirschfeld. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, German Federal Republic. Price DM.6.750.

Worked Examples in Applied Mechanics. By W. C. Durney. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, London, W.C.2. Price 12s. 6d.

Electrical Engineering Theory and Practice. Second Edition. By W. H. Erickson and N. H. Bryant. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 64s.

Symmetrical Components Applied to Electric Power Networks. By G. O. Calabrese. The Ronald Press Company, 15, East 26th Street, New York, 10, N.Y., U.S.A. Price 12 dollars.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

RATING AND TESTING OF REFRIGERATION COMPRESSORS

No. 3122 : 1959. Price 7s. 6d. This standard specifies and describes four primary methods of test and five confirming tests which must be employed in assessing the performance of a compressor. The rating is taken as the performance during the selected primary test and is not published unless the selected confirming test falls within the allowable limits. Both tests are run concurrently. The primary and secondary tests are required to be conducted under specified conditions, both inside and outside the compressor, and provisions are made to ensure that reproducibility of results is practicable.

Standard methods for the determination of ratings will ensure that purchasers of compressors, particularly of those intended for the larger installations, have a satisfactory comparative basis for, say, the assessment of tenders. The test conditions within the compressor are expected to be as near as practicable to those required by the selected group of application conditions, so that, when manufacturers publish their ratings under the terms of this standard, the purchaser will be provided with the information necessary to guide him in the selection of a compressor to meet his requirements.

ADDENDUM TO B.S. 752 : 1958 : TEST CODE FOR ACCEPTANCE TESTS FOR BACK-PRESSURE, PASS-OUT AND MIXED-PRESSURE STEAM TURBINES

Price 1s. This addendum to No. 752 : 1958, "Test Code for Acceptance Tests for Steam Turbines" extends the function of the parent volume to include tests for back-pressure, pass-out and mixed-pressure steam turbines.

The addendum has been prepared in a form which is related to the sections and clauses of the specification, and includes instructions for the insertion of the additional matter.

GAS AND DUAL-FUEL ENGINES

No. 3109 : 1959. Price 6s. The six types of engine dealt with in this new publication are : gas, convertible gas, gas diesel, convertible gas diesel, dual fuel and alternative fuel. The main clauses specify : rated power output and speed, permanent and temporary changes of governed speed, declared fuel consumption, tests (fuel consumption, governor, &c.), test records, inspection after tests, and responsibility for torsional vibration conditions. (Limits of cyclic irregularity and regular deviation in parallel running are specified for use where an engine drives an electrical generator.) As with liquid fuel engines, the basis of rating is continuous running. The combined effects of variation in atmospheric conditions and fuel gas composition are so complex that the ready application of a comprehensive method of derating is not practicable, hence no derating tables are provided.

Advice on information which should be supplied by the purchaser and manufacturer, on the mechanical output needed to provide a given electrical output, and on safety precautions, is given in appendices to the standard.

ALLOY STEEL CHAIN, GRADE 60, FOR LIFTING PURPOSES. GRADE 80, POLISHED SHORT LINK CALIBRATED LOAD CHAIN FOR PULLEY BLOCKS

No. 3113 : 1959. Price 5s. No. 3114 : 1959. Price 6s.

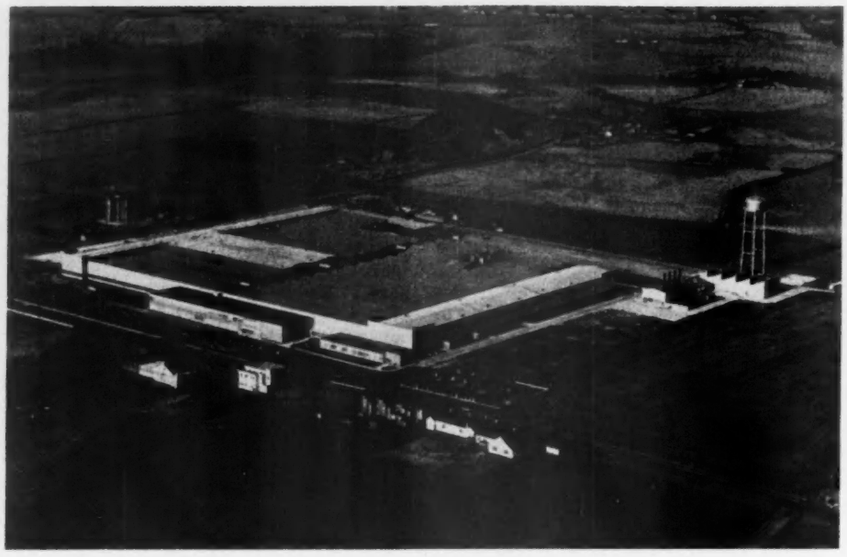
The high-quality alloy steel Grade 60 chain, with a nominal breaking load of $60d^2$ tons (where d is the size in inches) is the strongest lifting chain standardised. It is twice as strong as mild steel chain, Grade 30 (B.S. 590), and half as strong again as higher tensile steel chain, Grade 40 (B.S. 1663). It will form a component in the standard for alloy steel chain slings, which is in course of preparation. Grade 80 pulley block load chain, with a nominal breaking load of $80d^2$ tons is a new departure in this field. It is twice as strong as higher tensile chain, Grade 40 (B.S. 1663), hitherto the strongest standard for this purpose.

B.S. 3113 specifies requirements for material, dimensions, heat-treatment, workmanship, proof loading, breaking tests, energy absorption and marking, of the chains

In B.S. 3114 link dimensions are controlled within closer limits than hitherto and a check is established on overall length by means of a mould gauge. This provides a new degree of interchangeability, and advantage will be taken of it in the forthcoming standard for hand-operated chain pulley blocks.

Both publications have appendices dealing with inquiry and order, contracts, certification and safety principles; and with instruments developed by the National Physical Laboratory for measuring the true mean diameter of links.

Tractor Factory at Tannochside



Just over a year ago, a modern factory was completed at Tannochside, near Glasgow, for the production of tractors by the Caterpillar Tractor Company, Ltd. The first "Caterpillar" tractors were built over fifty years ago in the U.S.A. where the company still has several plants. The Tannochside factory is operated by a British subsidiary of the American company.

IN 1925, a fusion of the activities of two American tractor and farm machinery manufacturing concerns resulted in the formation of Caterpillar Tractor Company, at Peoria, Illinois. The two constituents of this amalgamation were the C. L. Best Tractor Company and The Holt Manufacturing Company, both of which were founded in the middle of last century. By the 1880s both companies were turning out a variety of agricultural and other equipment. The Holt Company, for example, produced a "link and vee-belt combined harvester" which, it is recorded, was drawn by thirty-three mules and required five men to operate it. The Best Agricultural Works, established at San Leandro, California, completed its first steam-driven harvester early in 1889; the equipment consisted of two main parts, namely, a traction engine and a combine-harvester. The total weight was about 11 tons and the two driven wheels of the traction engine were 8ft in diameter and 2ft 2in wide. The claim made for this giant machine was that, at a travelling rate of 3 miles an hour, a cutting width of 25ft was maintained and from 65 to 100 acres could be harvested daily. Straw, wood or coal served as fuel and a crew of six was needed for operating the harvester. They included a driver and fireman for the traction engine, a "sack sewer," a header tender, an overseer, and a man with a team of horses or mules to transport fuel and water behind the machine.

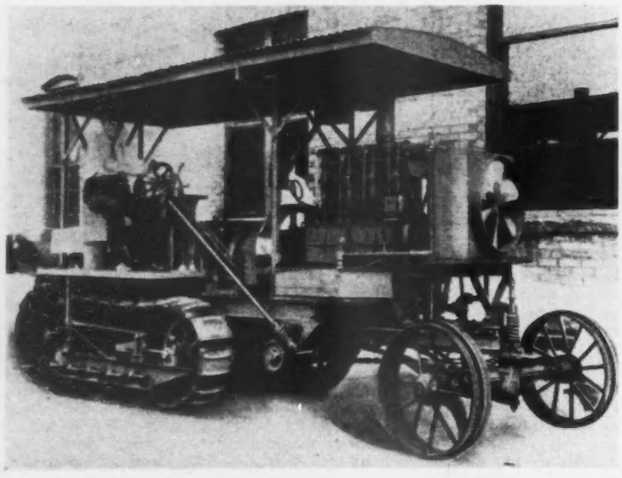
Early "Caterpillar" Tractors

By the turn of the century, both Holt and Best were building steam traction engines for haulage and other duties in all kinds of terrain. Most of them were three-wheelers, the two driven rear wheels being extremely wide and of large diameters. But the difficulties of manœuvring these cumbersome machines on soft land were soon evident and the idea of a tracklayer was developed. In 1904, the Holt Company removed the large rear wheels of one of its steam tractors and replaced them with a pair of tracks. Each track frame was 2ft 6in high, 3ft 6in wide and 9ft long, the tracks consisting of wooden slats each measuring 3in by 4in.

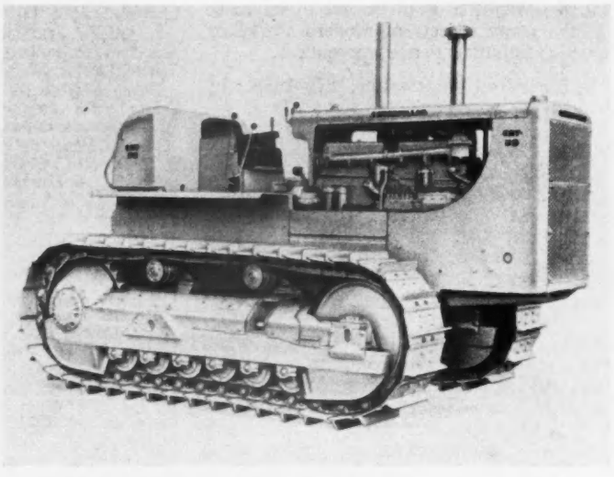
Two years later, Holt produced at Peoria an experimental "Caterpillar" gasoline traction engine. The first production model went to work in 1908 on the Los Angeles Aqueduct and by 1910 more than a hundred of these "crawlers" were in operation. One of the tractors is illustrated herewith. It was powered by a petrol engine, with four cylinders, 6½in by 8in, developing 45 b.h.p. at 550 r.p.m. In a description of this tractor (THE ENGINEER, April 14, 1911) we explained that the track chain was composed of wide steel links connected by pins, the outer face of each link having "a hood plate, shod with a corrugated steel shoe." The track length was 7ft and the weight of the tractor in working order was 8 tons.

Recent "Caterpillar" Developments

We have included this reference to the first crawler tractors built and operated in California to recall that Caterpillar Tractor Company and its antecedents have been



The first "Caterpillar" tractors (1908) were equipped with four-cylinder, 45 b.h.p. petrol engines



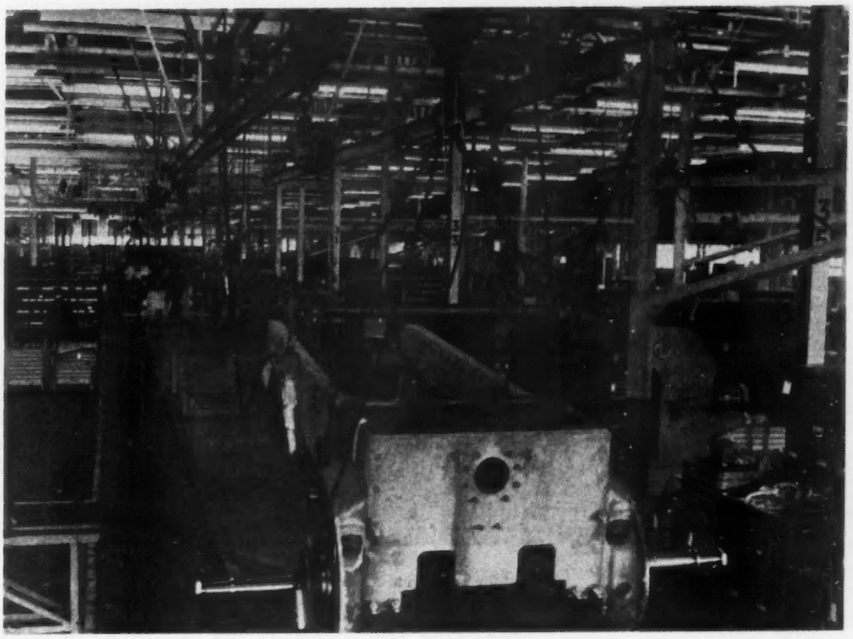
The "D8" tractor now in production at Tannochside is a 225 h.p. machine

producing this kind of machine for fifty-five years. In the period since the second world war, a British subsidiary, Caterpillar Tractor Company, Ltd., has been formed and for some years has operated two establishments in this country, a spares and accessories factory at Desford, Leicestershire, and a factory at Birtley, Co. Durham, for building various items of earthmoving equipment.

But until recently the company has had no facilities in the United Kingdom for crawler tractor production. To fill that gap, it has built and equipped a modern factory at Tannochside, near Glasgow. Tannochside was formerly a mining village and, following the closure of a number of coal mines, Caterpillar Tractor Company, Ltd., was able to acquire a site of 65 acres, the decision being influenced by the fact that sufficient raw materials and labour were readily available there to expedite the construction of the plant. The work was started in June, 1956, and exactly two years later the first "Caterpillar" tractor to be built at the Tannochside plant came off the assembly line. It was a D8 tractor, the production of which is at present the principal activity of the new factory.

The latest version of the D8 diesel tractor is illustrated herewith. It is equipped with a six-cylinder turbo-charged diesel engine, 5¾in bore and 8in stroke, with a displacement of 1246 cubic inches. The engine is rated at 225 h.p. at the flywheel and 180 drawbar h.p. The track roller frame is a four-piece box section construction; there are six rollers on each side and the length of the tracks on the ground is just over 9ft 6in. The tracks can accommodate shoes up to 28in wide.

The transmission is pressure-lubricated throughout with filtered oil. Engine oil is used for lubricating and cooling the transmission, bevel gearing and steering clutches, the compartments housing these components being interconnected to form a common oil sump which is serviced by a two-section pump. Oil from the front section of the pump provides for the boosting of the steering brakes and the oil pumped by the rear section is full-flow filtered after which a portion of it is used to actuate the steering clutch control and lubricate the control, bevel gear pinion and shaft bearings. The filtered oil flows through a water-cooled heat exchanger to a transmission manifold which controls pressure lubrication of the transmission bearings, gears and shafts. The steering clutches and brakes are cooled and lubricated by operating in the reservoir of oil in the sump. The final drive gears and bearings are pressure lubricated by the use of a final drive sump, oil pump and filter. The transmission of the latest D8 "Caterpillar" provides for direct forward and reverse gear selection in six speeds, between 1·5 and 6·3 m.p.h. To assist easy operation of the tractor the steering clutch and governor control levers are mounted on a console convenient to the driver. The multiple disc steering clutches are hydraulically actuated.



The tractor assembly line

The Tannochside Factory

The aerial photograph reproduced on page 106 gives some indication of the present extent of the new factory at Tannochside. As already mentioned the site acquired by Caterpillar covers 65 acres. So far, buildings occupying 16 acres have been erected and fitted out, one single building covering no less than 13 acres. This latter building contains the main factory on the ground floor and incorporates a spacious mezzanine floor. This mezzanine floor extends across the full width of the factory and houses employees' locker and toilet rooms, a well-equipped kitchen and a cafeteria with seating capacity for 700. In the construction of the buildings, the use of brick, externally, has been kept to the minimum; in its place insulated metal "sandwich" walling has been extensively used. The roofs are aluminium, with north-light glazing. The office and personnel administration blocks are accommodated in two buildings attached to the factory, the former being on two floors and the latter a single-storey structure. Within the office block there is an auditorium complete with stage and in the main factory there is a separate sound-proof building which is used as a conference room.

Throughout the factory, careful attention has been paid to the welfare of all the employees. In all departments there is plenty of room to move about and in many areas the flooring is composed of wood paving blocks as an aid to more comfortable working conditions. In those parts of the factory in which completed tractors are moved about a flooring material known as "Korodur" has been used. The mechanical handling systems are on an extensive scale.

At one end of the machining area there is a metallurgical laboratory through which all the raw materials pass for testing by the company's quality control department. As they leave the machining section of the factory all components pass to an inspection area adjacent to the assembly lines. There are two assembly lines, one for engines and the other for tractors. In both cases, the arrangement is a main assembly line with sub-assemblies feeding into it at various points. The accompanying illustrations of portions of the machine and heat treatment areas and of the tractor assembly area show the spaciousness of the plant and the extent of its equipment. At the end of the

Part of the machine shop area

The heat-treatment area

tractor assembly line there is a space fitted out with armour-plated steel skidpans for " running in " of the tracks.

A particularly interesting part of the Tannochside factory is the heat treatment plant. In a Birlec cyclic annealing furnace installation, shown in one of our illustrations, several stages in the complete heat treatment cycle, hitherto carried out separately, are performed in automatic succession on a predetermined time-temperature schedule. This furnace is used mainly for the heat treatment of forgings prior to machining and final heat treatment. Two annealing cycles are involved, namely, a normal anneal and an isothermal anneal in which the work is fast-cooled to an intermediate temperature within the range 600–700 deg. Cent., held there for a specified time and subsequently slowly cooled to discharge. A third heat treatment cycle is possible and involves fast cooling from the austenitising temperature to temperatures in the region of 350–400 deg. Cent. in a period of twenty minutes.

The equipment consists of a furnace with a heating chamber, fast-cool chamber, holding chamber, water-cooled chamber and a spray quench section, the charge being conveyed through the whole by a series of driven rollers. The rollers are driven by a Carter unit with a variable gearbox, from the output shaft of which a chain drive is connected to a line shaft ; the drive from the line shaft is by a chain to a number of worm reduction units from which there are further chain drives to each of the rollers. With a usable conveyor width of 42in and a loading height of 22in above the rollers, the furnace is capable of an output of 2000 lb per hour. Work is carried on cast nickel-chromium alloy trays 42in square, loaded to about 2000 lb each. Certain sections of the roller track can be accelerated from normal speed to fast speed, to transfer trays quickly from one section to the next. Having heating elements, totalling 475kW, divided into six separate zones, the furnace is controlled by Honeywell Brown instruments. For a permanent record three point recorders for the heating and slow cooling chambers and a single-point recorder for the fast-cool chamber are provided. Insulated doors are fitted at the charge end of the furnace and at the end of the water-cooled section, with an intermediate door between the heating and fast-cool chambers. All the doors are automatically motor operated. A large axial-flow fan is fitted in the roof of the fast-cool chamber and is automatically controlled for the varying cycles. This fan works in conjunction with a series of air cooling tubes, inserted into the side wall, which are fed by means of a blower mounted externally above the furnace. The spray chamber, which is built of non-corrosive material, has water sprays in the roof and a tank reservoir beneath the rollers ; the water is recirculated by a thermostatically controlled pump mounted at the side of the chamber. The water-cooled section is double jacketed with the water circulating through the side walls and hearth. The roof has a removable water-cooled tank sitting in a bitumen seal.

The operator loads a charged tray on to the furnace charge table, pushes it forward until the leading edge operates the charge table flap switch. The tray waits in this position until the tray immediately inside the charge door of the furnace has moved forward to permit charging of a new tray. As soon as the space is available, the charge door opens and the fast drive is automatically started to move the tray from the charge table into the furnace until it is stopped by a photo-switch, and the door is closed behind it. The tray is then carried through the heating chamber at normal roller speed until it breaks the light beam of the photo-switch in front of the fast-cool section. This switch opens the door starting the fast-cool section high-speed drive, which moves the tray forward into the chamber until it is stopped by another photo-switch and the chamber door is closed behind it. When the door is fully closed the cooling blower and the axial-flow fan motors are started and run for a predetermined time.

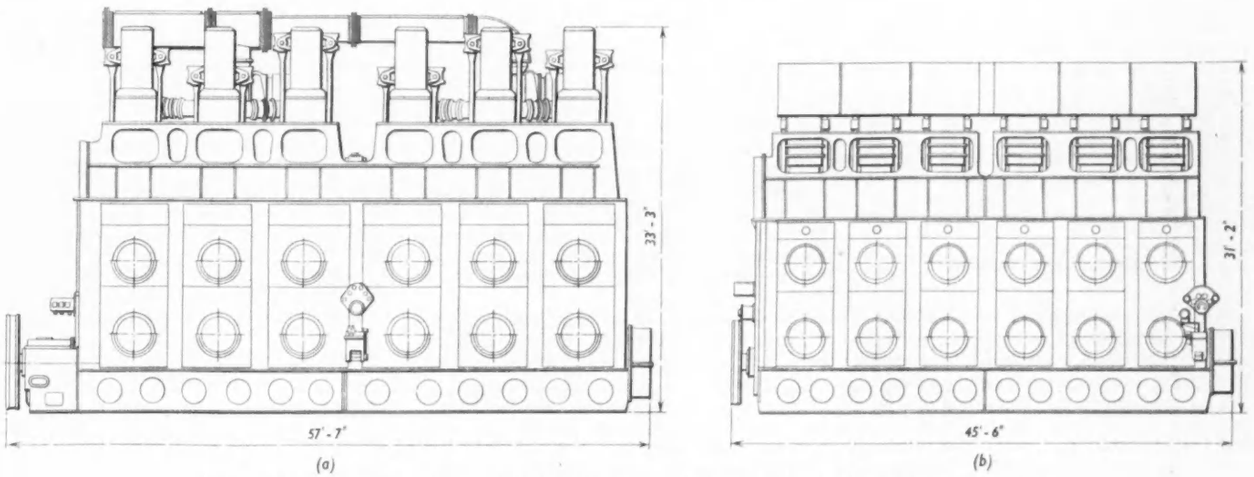
During the cooling cycle the charge continues to move forward at normal speed until the following tray operates the switch in front of the chamber door. When this tray is driven into the chamber the leading tray, which is almost out of the chamber, is driven at high speed towards the discharge door. The tray then travels at normal speed until it breaks the beam of the photo-switch in front of the discharge door. The door then automatically opens and the fast speed drive carries the tray clear of the furnace into the spray chamber where the leading edge operates a flap switch which stops the fast drive and closes the door. The sprays in the spray chamber then start automatically and run for a set time, at the end of which the fast drive takes over and discharges the tray. The second cycle has a similar sequence of operation except that the fast cool section is made inoperative. Both cycles can, if necessary, be operated by a series of control buttons mounted on the control desk, which also contains the auto-manual changeover switch, timer and indicating lamps which show the position of the trays within the furnace, i.e. whether or not the door approach switches are clear or about to operate.

The normal annealing cycle is used for medium and high-carbon steels such as S.A.E. 1040 and S.A.E. 1080. In the main, the forgings thus treated are for such components as con-rods, levers and pawls which are hardened and tempered after machining. The advantages of this preliminary anneal are the obvious ones of grain refinement and machinability. These same advantages are obtained by the isothermal annealing, but the forgings thus treated are generally of heavier section and take the form of shafts and gear blanks. As would be expected, such components are ultimately carburised and hardened and the grain refinement helps in the attainment of uniform carburising and in limiting distortion on subsequent quenching. The steels used are plain carbon carburising steels such as S.A.E. 1018 and low-alloy carburising steels such as S.A.E. 8720H and S.A.E. 8622. The forgings vary in weight from 10 lb to as much as 250 lb for a large gear.

High Powered Doxford Engine

Progressive development of the Doxford engine since the introduction of the mark 65 L.B.D." S "6 has resulted in the production of a turbo-charged engine operating without scavenge pumps. This is a mark 70 L.B.D." S "6 engine having a bore of 700mm by 2320mm combined stroke and a maximum rating of 10,450 b.h.p. at 120 r.p.m.

SINCE the completion, towards the end of 1957, of the first Doxford-built turbo-charged engine, which was also the first of a new series and designated 65 L.B.D."S"6, progressive development has resulted in the production of the first turbo-charged unit to operate without scavenge pumps. Originally reciprocating scavenge pumps had operated in series with the turbo-blowers, but tests on engines in service at sea demonstrated that the scavenge pumps could be disconnected and that the engines would continue to function with only minor modifications. Shop trials of this six-cylinder engine, seen on the test bed in our illustration, which is the highest powered Doxford engine built to date, were run in June and the engine itself is fundamentally an established standard unit having a bore of 700mm, the stroke of the upper and lower pistons being 920mm and 1400mm respectively, to give a combined stroke of 2320mm. The maximum rating is 10,450 b.h.p. at 120 r.p.m., with a m.i.p. of 116 lb per square inch gauge and equipped with two Brown Boveri V.T.R. 630 turbo-chargers. This output is obtained under test



(*a*) Six-cylinder, 700mm bore by 2320mm stroke turbo-charged engine (reduced cylinder centres). Weight of engine 480 tons.
(*b*) Six-cylinder, 670mm bore by 2100mm stroke turbo-charged engine (future). Weight of engine 375 tons.

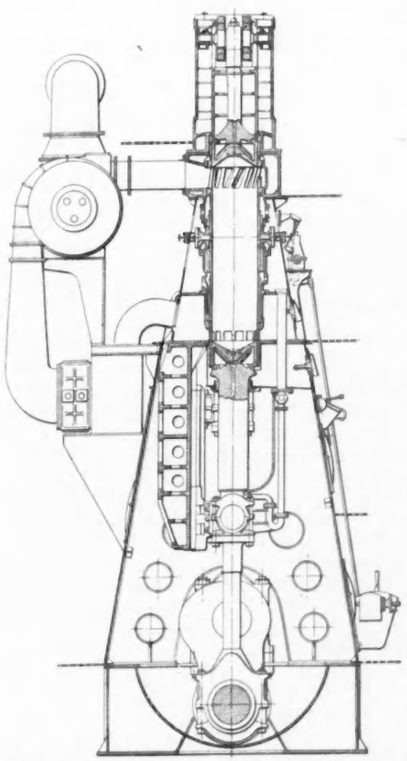
Profiles of reduced-cylinder-centre engine and future engine

bed conditions and for continuous sea service the recommended output is 90 per cent of the above rating. The elimination of the scavenge pumps has resulted in an engine having a cleaner and simpler layout and reduced weight. Furthermore, as the result of experience with turbo-charged engines in service, it has been found possible to reduce the overall length of the engine by reducing the distance between the cylinder centres without adversely affecting performance or reducing accessibility. Thus, the engine on test is 30 tons lighter than the existing design which also represents some saving in cost. Each blower is connected to three cylinders and to augment the supply of scavenge air under conditions of slow running, and also to ensure that the engine will continue to run with one or both blowers out of action, two auxiliary fans are fitted, each driven by a 30 h.p. motor. For slow running, only one fan is required, but in the event of failure of the blowers, both fans could keep the engine running at 70 r.p.m. Without the use of a fan, it is possible to run the engine at about 30 r.p.m.; however, with one fan in operation, revolutions can be reduced to 22 r.p.m. to meet special conditions obtaining in a canal or requirements for heavy manœuvring.

The general construction of the engine, of which we include a cross section, does not differ from established practice; the bedplate is of welded steel plate, built in two sections and bolted together, and having the crankshaft main bearings, consisting of steel shells white-metal-lined, spherically mounted. Diaphragm chambers are incorporated in the entablature which forms a scavenging air receiver and a support for the exhaust belts and top guides. The columns are fabricated from steel plate and provided with facings for attaching centre and side cross-head guides. Vanadium titanium cast iron is used for the cylinder liners, around the upper and lower parts of which are fitted cast iron jackets for water cooling. Both upper and lower pistons are of solid forged ingot steel, the former having a cast iron skirt and being water cooled, while the latter are arranged for oil cooling. The crankshaft, in two sections, is of solid forged ingot steel and the side connecting rods and centre connecting rods are of similar material, the top end and bottom end bearings being of cast steel lined with white metal, the latter bearings being spherical.

A chain from the aft end of the crankshaft drives the high-quality steel camshaft which is in two sections and incorporates cams to operate fuel injection system timing valves, cylinder lubricators and indicator gear, while a bevel wheel drives the air starting distributor. Starting is by air and two pilot lines, one for ahead and one for astern, from a block on the front of the control box are connected to the rotary air distributor situated on the camshaft platform. From this point connections are made to air starting valves at each cylinder. Fuel is pumped to a distribution block at the control station and then passes via accumulator bottles, one per cylinder, to the fuel injection timing valves controlling the injectors. The main fuel pump which has a forged steel body is roller chain driven.

Forward thinking by the company to reduce still further both length and weight of the engine has resulted in a new design of engine being evolved. A six-cylinder turbo-charged prototype engine is now being built and it is hoped to commence shop trials towards the end of this year. The table gives particulars of the new engine compared with present designs.



High powered Doxford engine 700mm bore 2320mm combined stroke

70.LBD. "S" 6 engine on test bed

	Existing design	Reduced centre design	Future design
Number of cylinders	6	6	6
Bore in mm	700	700	670
Stroke, mm	2,320	2,320	2,100
Maximum b.h.p.	10,450	10,450	10,800
Rating :			
R.p.m.	120	120	130
M.i.p.*	116	116	135
Overall length	61ft 1½in	57ft 7in	47ft 6in
Width of bedplate	12ft 4½in	12ft 4½in	12ft 2in
Overall height	33ft 7½in	33ft 3in	31ft 2in
Weight, tons	510	480	375

* Pounds per square inch gauge.

From the above figures and the accompanying elevations of the engines, the considerable saving in both length and weight effected by the new design is clearly indicated. The reduced length has been obtained by a reduction in the length of the bearings to give a shorter and stiffer crankshaft. Bearing diameters have been increased, resulting in a greater overlap of the side crankpins and journals, and, in view of the rigidity of the crankshaft combined with the short length of the bearings, spherical bearings have been eliminated. The two-piece crankshaft will be joined by a single large diameter coupling. It has a high natural frequency of both torsional and axial vibration such that no detuner will normally be necessary on engines having less than six cylinders. The cylinder liners are in two pieces ; the upper and lower ends containing exhaust and inlet ports respectively, are clamped by upper and lower jackets to a central cast steel combustion chamber. Both the centre and side cross-heads are of simple construction and in a normally aspirated engine the scavenge pumps will be driven from the latter. Cooling of the lower piston is by lubricating oil through trombone tubes and the small diameter piston rod is used with an improved diaphragm gland. The upper piston is water cooled.

Compactness of design has permitted the exhaust to be led away from the exhaust belts through a double pipe arranged between the cylinders, and on the turbo-charged engine they are connected to the turbine inlet and, being as short as possible, give the highest power impulse to the turbine. The exhaust pulse energy available has been further increased by the increased lead of the exhaust crank, the means adopted to eliminate the need for engine-driven scavenge pumps. As stated in the table giving the synoptic details, the engine has been designed to run at speeds up to 130 r.p.m. and will develop 1800 h.p. per cylinder, the output in normally aspirated form being 1300 h.p. per cylinder.

Some Developments in Piling

Demonstrations were recently held at the Claydon works of the British Steel Piling Company, Ltd., of several new developments which the company has introduced. Visitors were able to see a machine for manufacturing helically-welded tubes from steel strip, a hydraulically-operated piling frame of advanced design, and a heavy diesel piling hammer. The last two were in use together driving a helically-welded steel tube to form a " cased pile."*

A SYSTEM of concrete bearing piles has been introduced by the British Steel Piling Company, Ltd., which uses a steel tube of thin gauge, formed by helically welding cold-formed strip. The tubes may be 10in to 28in in diameter, virtually of any length and from 11 gauge (0·116in) up to ⅜in in wall thickness. A shoe is fitted to the base of the tube, which is then driven like a normal pile, and finally filled with concrete. The pile is known as a " cased pile."

These comparatively thin tubes are successfully driven by using a driving cap with a tapered spigot fitting into the top of the tube. The larger diameter of the taper is greater than the internal diameter of the tube, so the effect of the spigot is to induce a hoop tension in the top 6in or 9in of the tube, and it is this effect which prevents the tube from buckling under the hammer blows. In fact, we are informed that tubes have been subjected to very hard driving without buckling. The pile shoe may be a flat plate welded to the tube or a cast iron conical-shaped shoe, also provided with a tapered spigot. The pile may also be driven internally, with a drop hammer striking a plug of concrete in the base of the tube.

The cased pile is considered to have several advantages. It can be driven with a relatively light hammer, since only the weight of the casing has to be driven, and it can be obtained in any required length. A site butt-weld can be made to increase the length of tube already driven, or a driven tube can be simply cut. Thus flexibility in use, with light equipment such as leaders mounted on an excavator, is one of the main aims of the system. The driven tube may also be inspected visually prior to concreting, and the tubing clearly protects the newly-placed *cast-in-situ* concrete.

A special machine, described more fully on page 122 of this issue, has been installed at Claydon for making the " Helical-weld " tubes used for the cased pile and other applications. This machine forms and welds tubes continuously from coiled steel strip, which, after straightening, is forced into a semi-cylindrical former, inclined at about 45 deg. to 65 deg. to the line of feed. In this way a closely coiled helix is obtained, the joint of which is welded by inner and outer automatic welding heads using the submerged-arc process. So far, 85ft lengths of tube have been produced without difficulty, and it is thought that lengths of 120ft or so are practicable before control difficulties begin to appear on the machine. The machine produces tube at a rate of about 2ft 6in per minute, the rate varying with the tube diameter and thickness.

The piling frame in use. A length of helically welded casing is being driven using the diesel piling hammer. Note the guide sleeves for the hammer and the casing, and the driving cap

* See " Spiral Tube Welding Machine," in this issue, page 122

Hydraulically-Operated Piling Frame

The clean lines and somewhat unorthodox design of the piling frame shown at the company's demonstrations are well brought out in the accompanying illustrations. A particularly novel point in this design is the provision of walking gear so that the frame can travel independently of rails or any outside source of power. Basically it consists of upper and lower circular base frames, the upper one turning on the lower one. The upper frame carries tubular leaders, with a head sheave unit. In the centre of the base is the walking gear, and the control cab, the power unit and the winch drums are overhung at the back. Operation of all the movements of the frame is hydraulic.

The leaders are 67ft in height (i.e. there is around 50ft under the piling hammer) but a maximum height of 90ft is possible for this unit. The frame will handle a 4-ton hammer and a 6-ton pile, or an equivalent combined weight. The weight of the frame itself is about 20 tons and it can be dismantled into large but convenient units for transport between sites.

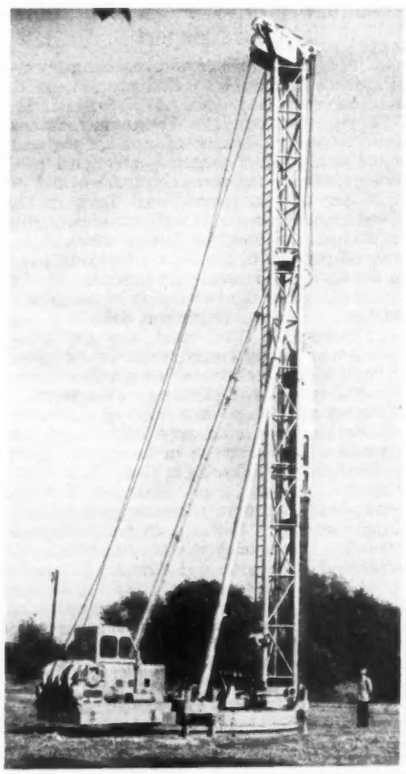
The leader unit consists of three longitudinal tubes, each of 6½in outside diameter, spaced to form an equilateral triangle of 2ft 9in side length, and interconnected by subsidiary tubular bracing. The base of the triangle (i.e. two tubes) are the guide members for the hammer and the pile. The hammer has resiliently-mounted guides, which slide on each of the two main tubes on horseshoe-shaped sleeves. Similarly, the collar holding the pile to the leaders slides on horseshoe-shaped sleeves on each of the two leader tubes.

The leaders are held by two raking struts, which are tubular, and each incorporates a hydraulic ram. The stroke of the ram is 55in, which makes a range of inclinations from 1 in 10 forward to 1 in 3 backward available on the leaders. In addition, the base of the leader unit is pinned to a slipper at the front of the upper base ring, where two horizontal hydraulic cylinders are built in to give a horizontal adjustment of 12in at the base of the leaders. This adjustment may be used to position the pile precisely prior to driving, or to correct for " drift " during driving. The leaders may be dismantled into three 19ft lengths, plus the two raking struts, the head sheave, the base unit, and a lower leader extension ; seventeen muff couplings are needed to assemble all these elements.

The two base frames each consist of rings of box section, resting one on top of the other. The outside diameter of these rings is 15ft 8in. The leader unit and the machinery are all carried on the upper ring, which may be rotated on the lower ring through specially lubricated surfaces. The drive for rotation is a hydraulic motor driving a sprocket which engages with a chain fixed to the circumference of the lower ring.

The lower base ring rests on the ground, but four pairs of hydraulic jacks acting on ground bearing plates and mounted on the upper base ring are provided to level the plant when it is in operation. The two front pairs of jacks are disposed on either side of the leaders and operate together from one valve. The two rear pairs, one under each back strut, operate independently.

The hydraulic walking gear is carried on an inner ring, integral with the upper base ring. It consists of two inclined hydraulic jacks hinged to the frame on the upper base ring (above which it projects, as can be seen in one of the illustrations), and to a baseplate through which a force can be applied to the ground. Operation of the jacks tends to lift both base



Hydraulically-operated piling frame

rings, at the same time applying a horizontal force to move the frame forward. The walking gear is self-contained, and may be rotated by power through one full turn in either direction relative to the base structure to give any direction of travel. When the plant is in operation, the walking gear is retracted within the base.

The piling frame is powered by a Fordson six-cylinder diesel engine coupled to a dual hydraulic pump operating at 1450 r.p.m., at which speed 59 h.p. is available. The pumps are capable of delivering 32 and 8½ gallons per minute independently at 1450 r.p.m.

Each of the two winches consists of a grooved drum 2ft 2in diameter by 1ft 7½in long driven by a 30 h.p. hydraulic motor through a 50 : 1 worm reduction gear. The drums will each accommodate 150ft of ¾in diameter steel wire rope and are designed to lift 3 tons singly at a speed of 100ft per minute. There are no brakes or clutches as the system is self-sustaining ; the drums may be rotated in either direction under power by operation of the appropriate control valves. Hoisting, rotating and raking motions are operated by the larger pump, but lesser outputs are required for travelling, leader sliding and jacking. The total capacity of the hydraulic system is about 25 gallons.

The piling frame just described was demonstrated at work driving a cased pile, using a McKiernan-Terry diesel hammer, which is now being manufactured by the company. The hammer is in two sizes, the larger of which has a ram weight of 2800 lb, and an average striking energy of about 16,800ft-lb per blow. The hammer is single-acting, operating at about fifty strokes per minute with a maximum stroke of 8ft and a maximum striking energy of 22,400ft-lb per blow. Visitors were also able to see a heavy-duty pile extractor, the HD 15, in use. This device was described quite fully in THE ENGINEER of November 23, 1956.

Static Exciter for Marine Alternators

THE "Accurex" static exciter made by The General Electric Company, Ltd., of England, is claimed to be specially suitable as a self-regulating system for alternators on shipboard where rapid response, minimum overall length and reduced maintenance are of prime importance

In this system there is no rotating exciter but the alternator takes its excitation from its own output fed through a metal rectifier and other simple static components as outlined in the basic circuit diagram : a single-phase machine is considered for simplicity.

When the alternator is running on no load, the terminal voltage of the alternator is applied to the d.c. controlled saturable reactor CR. The reactor current I_R will depend on the alternator voltage V and will lag by about 90 deg. This current passes through the compounding current transformer CT and the metal rectifier *MR* and supplies the required no-load field excitation.

When the alternator is supplying power, the load current passes through series coils on the compounding current transformer. The secondary current of this transformer is then the vector sum of the reactor current and a current proportional to load current, as shown in the vector diagram which applies to load power factors of (*a*) unity and (*b*) 0·8 lagging. It will will be seen that as the load power factor falls the excitation is automatically increased. By correct proportioning of these currents the excitation given by this static excitation circuit will be approximately correct for all normal loads down to low lagging power factors.

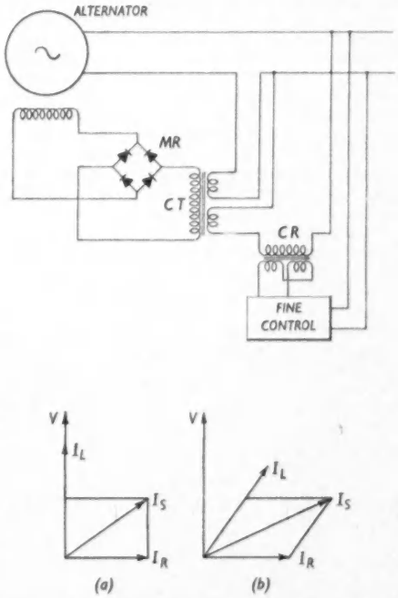
The d.c. excitation of the controlled reactor is supplied from a magnetic amplifier fine control circuit and, as considered above, is assumed to be constant. However, the fine control circuit is designed to adjust this d.c. excitation and hence the a.c. current of the reactor if the alternator voltage tends to vary from its correct value. To ensure initial build up of the alternator voltage from its residual value, a relay short circuits the controlled reactor until the alternator voltage rises to about 50 per cent of normal.

A transient change of alternator voltage caused by the transient reactance is inevitable and occurs largely during the first cycle. Because the field windings are effectively connected in series with the alternator output by means of the series winding on the compounding current transformer, the field current must build up almost as quickly as the load current and a high forcing voltage will be produced across the field inductance to enable it to do so. Thus the magnitude and duration of alternator voltage disturbances are kept to a minimum.

To illustrate the performance of alternators controlled by "Accurex" static exciters we shall consider an example where a ship's a.c. system is fed by two 250kW, 312kVA, 450V, three-phase, 60 c/s, 514 r.p.m. alternators operating in parallel. If a 45 h.p. deck machinery motor is started direct-to-line on this supply, it will take a starting current of about five times its rated current, or about 225kVA, at a low power factor : this load will be 36 per cent of the total connected capacity. A maximum dip of 7½ per cent occurs and the voltage recovers to within 1½ per cent of its normal value within 0·35 second.

With a number of motors in simultaneous operation there may be occasions when two are started within the same 0·3 second period. In this event a maximum dip of 14 per cent might occur but recovery to normal voltage will be almost as fast. The foregoing results are for direct-to-line starting, which causes maximum disturbance on the system. If star/delta starting is used there is a correspondingly marked reduction in the severity of the disturbance. Where a load equal to 100 per cent of the total connected kilovolt ampere capacity but at a low lagging power factor is suddenly thrown on a voltage dip of 18 per cent occurs and the voltage recovers to normal within 0·5 second. The steady state voltage regulation of the set is stated to be to within ±1½ per cent of the nominal voltage under all normal conditions of load and power factor.

Under short circuit conditions a strong alternator excitation is maintained because of the effect of the load current on the excitation. Saturation of the static exciter components will limit the excitation to about 1·5 times the full load excitation and the sustained short circuit current will be about three times the rated



Schematic diagram for single-phase static exciter, with vector diagrams

current. This fact simplifies the design of the protective devices installed in the system.

The system is suitable for parallel operation of alternators, to share the reactive kilovoltage amperes in proportion to their ratings. For satisfactory operation, the prime movers should have similar characteristics of speed droop with load. A value of from 4 to 5 per cent for the speed droop between no load and full load is generally recommended.

The most common method of compounding is by quadrature droop using a current transformer connected in the output of each generator thus adding a voltage proportional to load current to the voltage being fed to the control circuit of the static exciter. The phase is chosen so that the total voltage signal is affected mainly by the reactive component of the load and is almost unaffected by the power component. This method of compounding is simple, but a voltage droop of about 4 per cent will occur between no load and full rated load on the system. If such a voltage droop is undesirable it can be reduced to about 1½ per cent by installing a somewhat more complicated switching arrangement for the compounding circuit.

SHORTER REPORTS

H.F. Transmitter With Wideband Amplifier

THE development of an amplifier which provides amplification over the whole of the h.f. band, 2 to 24 Mc/s, without tuning adjustments has enabled Marconi's Wireless Telegraph Company, Ltd., Chelmsford, to introduce a new 1kW communication transmitter offering a range of facilities with maximum simplicity in operation. Although there are two amplifier stages, frequency changes are made simply by switching at the drive unit, aerial commutation taking place automatically at the same time. The transmitter is a 1kW wideband h.f. communication equipment designated "HS113," incorporating drive unit, power supplies and cooling blower in a single cabinet 7ft high. It is considered that many point-to-point requirements will be met by two crystal-controlled drive frequencies, but this number can be increased and, by using more than one drive unit, it is possible to transmit simultaneously on several frequencies. The methods of transmission provided are single/independent sideband telephony, low-level double-sideband telephony, frequency-shift telegraphy, or c.w. telegraphy with on/off keying.

Modulation is applied to the transmitter at low level, so that the amplifier may be installed immediately adjacent to the aerial without incurring transmission line losses; connection to the drive unit is made by coaxial cable. This arrangement is convenient for comprehensive station working as it enables the drives to be installed at a control centre under the supervision of one engineer. While some reduction in signal strengths is involved in simultaneous working on different frequencies, the avoidance of transmission line loss already mentioned is a compensating factor. The fact that access to the amplifiers is not required for changing frequency is an advantage in marine installations, where the limited space available may be overcrowded if this equipment must be installed within immediate reach of the operators.

The principle of the wideband amplifier in the "HS113" transmitter is that of distributive amplification using an artificial transmission line in which the shunt capacitances are replaced by the valve capacitances. This has the characteristic of insensitivity to the nature of the load impedance, which may be mismatched to a degree corresponding to a 2:1 standing wave ratio. Inductance separating individual valves effectively isolates the valve inter-electrode capacitances, while the anode currents contributed by individual valves add up. The amplifier is of two stages, the penultimate stage operating in class A with a gain of 26 dB, and the final stage in class AB with a gain of 25 dB.

Churchill College Trust Fund

A RECENTLY issued progress report on the Churchill College Trust Fund, 55, St. Andrews Street, Cambridge, shows that the appeal launched fifteen months ago has yielded sums, received or promised, totalling £3,000,000. This support has come from more than 800 firms in industry, commerce and finance, from livery companies and charitable trusts, from over 150 individuals, and from the Governments of Australia and Nigeria. About 99·3 per cent of this financial support is from the United Kingdom. In the U.S.A. the United States Churchill Foundation has been set up to promote the interests of the college and to raise funds for its support.

To endow the college at the full scale intended, an additional £1,500,000 will be needed, but the response to the appeal has enabled the trustees to proceed with their plans.

Sir John Cockcroft is Master-Designate and will take up residence in Cambridge by October this year. Mr. J. S. Morrison, at present senior tutor of Trinity College, Cambridge, will become senior tutor in the middle of next year and is already working part-time for the College. Dr. P. G. Ashmore, Cambridge University lecturer in Chemistry and a tutor of Emmanuel College, will become tutor for advanced students in mid-1960; one-third of the students will be post-graduates.

The trustees, having bought from St. John's College a 42-acre site at the junction of Storey's Way and Madingley Road, have appointed Richard Sheppard, Robson and Partners as their architects; their design has been adjudged the best by a panel of assessors consisting of Mr. Basil Spence, Professor S. William Holford, Professor Sir Leslie Martin, Sir John Cockcroft and Mr. Noel Annan. The winning design presents an interesting variation on the traditional college theme of the sequence of enclosed courts. The central buildings, comprising hall, library, common rooms, and so on, are planned as a free-standing group, in a large court enclosed by the residential accommodation. This has the form of a series of smaller courts, partly cloistered and surrounded by sets of rooms two or three storeys high. The large population of the college is thereby broken down into small self-contained and social units. The drawings of all the competitors are on view at the headquarters of the Royal Institute of British Architects at 66, Portland Place, from August 13 to September 12.

Preliminary applications for entry (of undergraduates) in October, 1961, may now be made. Seventy per cent of the places available will be given to men who intend to read natural sciences, engineering, and mathematics. An entrance scholarship examination will be held in the academical year 1960–61. There will also be an entrance examination for those who appear *prima facie* to have a claim to be considered for admission. Applications should be made to Mr. J. S. Morrison, c/o Trinity College, Cambridge.

The trustees hope to have a building ready to house a few post-graduate students considerably before October, 1961.

Links Between Industry and Further Education

FOLLOWING the regulation made last March that all major establishments of further education should have governing bodies including substantial representation of industrial, commercial and other appropriate interests, the Minister of Education, Mr. Geoffrey Lloyd, has issued a circular to local authorities giving guidance on the make-up and functioning of such bodies. In the Minister's view, the governing body of a technical or commercial college should consist largely of people—whether members of the local authority or not—who have current experience of problems of industry and commerce relevant to the work of the establishment and an active interest in further education. To this end, substantial direct representation of employers and unions in industry and commerce is normally essential, and the Minister suggests that such representatives should account for not less than one-third of the total. The governing body of a college or school of art should reflect in its membership the functions and range of work of the establishment and the service which it gives to the community as a cultural centre. Those branches of industry and commerce served by the courses provided should be represented and the participation secured of distinguished artists and designers residing in the locality. It is considered most desirable that, in addition to representatives of organised groups, individuals who can make a valuable contribution by serving in their personal capacities should also be co-opted.

The Minister is of the opinion that it is not necessary for the chairman of the governing body to be chosen from among the authority's own representatives and considers that the election of the chairman from the representatives of outside interests or from the co-opted members is likely to encourage industry and commerce and the professional bodies to nominate to it persons of eminence and ability. The circular also recommends the extent to which the governing bodies should be given financial power, and be allowed to participate in the appointment of staff and the organisation and curriculum of an establishment.

Commonwealth Telecommunications Board Report

IN its eighth general report, covering operations from January 1 to December 31, 1958, and the accounts from April 1, 1957, to March 31, 1958, the Commonwealth Telecommunications Board records an increase of over 8·1 per cent in the total paid originated international telephone traffic of the partner countries, and of 21·65 per cent in international Telex traffic. Of the telephone traffic, 91 per cent originated in the United Kingdom for foreign destinations, while 93 per cent of the Telex traffic originated in the United Kingdom for Europe. In the United Kingdom the installation of seven new radio transmitters at Ongar was completed (see our February 27, 1959, issue), two new transmitters were brought into service at Criggion, and installation work on the four new Dorchester transmitters was well advanced. Re-equipment of the original short-wave building at Rugby was begun, and seven new transmitters are expected to be in service in the current year, the remaining six following in 1960. New radio-telegraph services were instituted between London and Khartoum (teleprinter) and between Hong Kong and Mindanao, in the Philippines (Morse). Direct telegraph transmissions were established to Nigeria and Ghana. All radio transmitting equipment of the Australian National Body is now capable of linear operation to enable independent sideband techniques to be used for telephone and phototelegraph circuits, and to carry channelled telegraph services as required. In New Zealand a fifty-four-aerial, triple-diversity, radial vee system has been brought into operation at Makara radio receiving station, near Wellington. The South African National Body opened during the year a new receiving station at Derdepoort, and a new transmitting station at Olifantsfontein. During the ten years since the organisation of the Commonwealth telecommunications system was agreed by the parties to the Commonwealth Telegraphs Agreement, 1948, the partner countries have spent more than £30,000,000 on development and expansion of their networks.

Kent Coast Railway Electrification

DURING the peak of the August holiday season the operation of train services on the newly electrified Kent Coast lines of the Southern Region, British Railways (see our July 31 and August 7 issues) has benefited from the time recovery capabilities of the multiple-unit rolling stock. The motor coaches of the four-coach express and two-coach, semi-fast units are powered by two English Electric motors, each rated at 250 h.p. (one hour) and 205 h.p. (continuous). An express unit has two motor coaches and a semi-fast unit one motor coach. The notching relays are set for currents of 360A in series at the low accelerating rate, 450A at the high rate, and 720A in parallel. Similar machines are fitted to the motor luggage vans used on Continental boat trains to Dover via Canterbury, to which we referred in our July 24 issue. So far, the regular multiple-unit workings on boat services have been the 10 a.m. from Victoria and the 2.25 p.m. from Dover Marine, although other

trains have been operated with this stock at the height of the season. Normally, one motor luggage van is attached at the rear of the down train and controlled in multiple with the other motor coaches in the formation. A boat train, therefore, has at least two additional motors of the ratings quoted above. At Dover the van is uncoupled and runs to the quayside under its own power, taking current from its battery after leaving the live rail. On the up journey the van is the leading vehicle and the train is driven from its driving cab, which is equipped similarly to the other motor coaches except for the additional battery control and charge facilities.

Canada–Newfoundland Microwave Link

THE first transmission of public television signals over a new microwave system between St. Johns, Newfoundland, and Sydney, Nova Scotia, took place on June 18 when the Queen and the Duke of Edinburgh arrived at St. Johns at the beginning of their visit to Canada. This microwave link extends over 524 miles and comprises twenty-three stations at intervals of twenty to thirty miles on the overland section, which traverses the island along the northern railway route. The 70-mile crossing of the Cabot Strait is the longest microwave over-water path in the world and here s.h.f. automatic space diversity equipment is used to meet the difficult conditions caused by the rise and fall of tidal water. This new system avoids the necessity for duplicated receivers or additional radio frequencies, and discontinuities introduced by switching are eliminated.

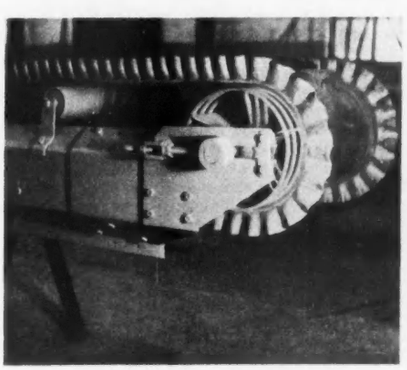
The whole system was supplied by Standard Telephones and Cables, Ltd. to the order of the Canadian National Telegraph Company. It is a multi-channel link operating at 4000 Mc/s with a nominal radio frequency power output of five watts and a total capacity of 600 two-way telephone circuits, one unidirectional television channel, and one two-way telephone and television standby channel. Back-to-back terminal equipments at Gander and Corner Brook allow traffic access for these districts. Altogether the system employs ninety-five one-way repeater and forty-two terminal equipments.

Belt Conveyor

A MULTI-PURPOSE belt conveyor built of standard prefabricated components is now being supplied under the trade name "Prefabor" by Numec, Ltd., New Whittington, Chesterfield. A troughed belt used on these conveyors has corrugated side walls 2in or 3in high, and is supplied in widths of 16in, 20in and 24in.

A conveyor of the required length is built up by assembling side pressings, made in standard lengths of 5ft, 6ft 6in and 10ft, and using pressed steel cross supports and end coupling plates. Belt support idlers mounted through brackets on the side members can be spaced in accordance with the conveyor duty. The drive of the belt can be adapted for an external drive by means of a motorised drum or a drum. At the return end of the conveyor the idler drum shown in the accompanying illustration is fitted. This drum is mounted on a tensioning bracket and comprises a "crowned" spiral element pulley which serves to centralise the belt on the main structure.

All parts of the conveyor are jig drilled for ready assembly using ⅜in bolts, and a conveyor can quickly be lengthened or shortened to suit requirements. It is pointed out by the makers that the troughed belt considerably increases the carrying capacity of these conveyors, which will work efficiently at steeper angles than those of conventional design. If required cross bars can be supplied for the belts when it is needed to work on steep inclines.



Troughed belt conveyor built to a required length with standard elements

Oil Terminal at Finnart, on Loch Long

THE recent opening of a new terminal and jetty at Finnart, on Loch Long, of which we reproduce an aerial view, for BP Refinery (Grangemouth), Ltd., marks the completion of a programme designed to increase the throughput of the Grangemouth Refinery from 2,200,000 tons to 3,200,000 tons per annum. Refining of crude oil commenced in 1924 at Grangemouth and additional units built in 1930 brought production to 360,000 tons a year at which level it remained until the completion of the enlarged refinery in 1952. During the post-war years the increasing demands for oil had been accompanied by an increase in size of oil tankers to well beyond the utility size of 12,000 tons, which could negotiate the tideway to Grangemouth. The expense of constructing jetties to reach deeper water was considered to be excessive and it was decided to build unloading facilities at Finnart, on Loch Long. A T-head jetty extending some 200ft into the loch was built, together with the necessary storage tanks and a 57-mile long pipeline, complete with pump houses, to link the oil terminal with the refinery. The pipeline is buried throughout its length and has an annual capacity of 3,250,000 tons, which is forced through under pressure by pumps situated at Finnart and Balfron. Of all-welded construction, the steel pipeline has a working pressure of 1000 lb per square inch.

Further enlargement of the Grangemouth refinery, together with the advent of the supertanker, indicated the need for improved facilities at Finnart, where there is ample room for manœuvring the biggest tankers and an adequate depth of water, and it was decided to build a second jetty. This and its associated storage tanks are located in an area, measuring 1000 yards long by 300 yards wide, at a point about half a mile south of the original installation. Steel piles varying in length from 28ft to 112ft have been driven 25ft into the bed of the loch to carry the concrete decking of the new jetty, which is 330ft long and sited some 180ft from the shore and parallel to it. The minimum depth of water at low tide is 55ft. At right angles to the jetty is the pipe track and also a shore arm to take light vehicular traffic, and on the jetty face are a number of flexible telescopic rubber block fenders. Additionally, there are four independent dolphins built on the shore line, two on either side of the jetty, together with two breast moorings.

For handling the oil there is a six-boom hose handling gantry, fitted with a fire-fighting monitor at each end. There are also monitors on towers at the ends of the jetty. Supplying the monitors are four 1000 gallons per minute centrifugal pumps which draw water from the loch. Foam is supplied by a separate system. Two 24in pipelines, permitting a discharge rate of 6000 tons per hour, connect the jetty with the four floating roof storage tanks which are fitted with two automatic high-level alarm systems. Provision has been made for the erection of two more tanks and the excavated material has been used to form bunds around the tanks. Particular care has been taken to seal the storage area to prevent any oil seepage through the underlying fissured rock into Loch Long, and this has involved surfacing the tank area with a concrete membrane.

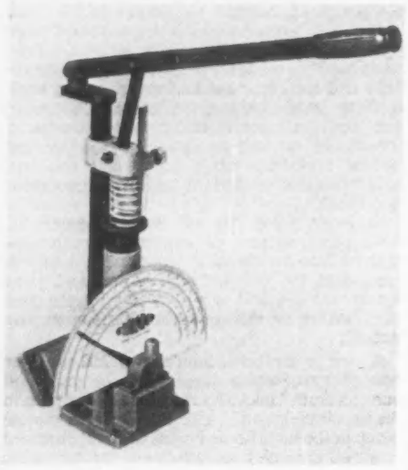
Drainage from the oil storage area and from other sources of contamination is discharged into an oil-water separator system. A road rings the new installation area and joins it with the old and is paralleled with the pipe track linking the storage tanks with the pumping station.

A new pump house houses two 250 tons per hour pumps, which supply fuel or diesel oil bunkers from tanks allocated for this purpose in the first installation. A 1000 gallons per minute pump in the same house is used to circulate stored crude oil through heaters to avoid the depositing of sludge. To provide supplies of potable water to the ship's tanks there is an 8in line and to provide adequate storage capacity the existing 100,000-gallon tank has been augmented by a 250,000-gallon tank.

Aerial view of the deep water terminal at Finnart, Loch Long, showing the new jetty and storage tanks

Spring Testing Instrument

A DUAL-PURPOSE instrument which can be used for testing springs and adapted quickly for checking torque wrenches, is now made by Jenks Brothers, Ltd., Britool Works, Wolverhampton. The basic spring testing instrument, illustrated below, has a pair of anvils between which a spring is compressed by a hand lever. The load applied on the spring is transmitted from the lower anvil through a master spring to a rack and pinion which operate a pointer. This pointer moves over a graduated dial which indicates the load applied in pounds and kilogrammes, and an adjustable rule on the moving anvil controls the length to which the spring under test is compressed. The instrument takes springs of up to 4in free length and its loading capacity is to 200 lb.



Testing instrument for springs up to 4in long

When it is required for checking the setting of torque wrenches the handle assembly is replaced by a lever attachment. A ¼in square drive socket on this attachment is coupled to a lever with a roller bearing at the end which registers on the lower anvil. The wrench is fitted on the socket and as a load is applied on the wrench handle it is registered on a pounds-inches or kilogramme-metres scale on the indicating dial.

Chromising Metal

WE are informed by Metal Diffusions, Ltd., of Isleworth, Middlesex, that it has developed an improved chromising process by which there can be produced on metals a depth of diffusion of between 0·001in and 0·015in, depending upon the metallic analysis of the article treated. With this "Dicrom" process it is stated that a high chromium purity is attained at the surface and surface purity values of 96 per cent are obtainable. It is pointed out, however, that for most commercial applications a diffusion depth of from 0·003in to 0·005in with a surface concentration of chromium of 60 to 70 per cent provides very satisfactory results.

The surface properties obtainable with the process ensure that in cases where special resistance to oxidation is required, at temperatures up to 1188 deg. Cent., mild steel can be treated to afford the same resistance to corrosion as that afforded by a 40 per cent nickel/22 per cent chromium alloy steel. Employing combined chromium/aluminium diffusion, effective resistance to corrosion at temperatures up to 1305 deg. Cent. is achieved by "Dicrom" treatment. When sulphur-bearing gases are present, adequate resistance to corrosion may be obtained by the process, followed by superficial high-temperature oxidation of the surface to chromic oxide.

In discussing the commercial uses of the improved process, the firm points out that the higher percentage of surface chromium it provides permits fuller use to be made of the physical properties of chromium. A surface so chromised can be electro-polished to produce a finish comparable with chromium plating, while retaining the advantages of resistance to heat and of inseparability from the parent metal.

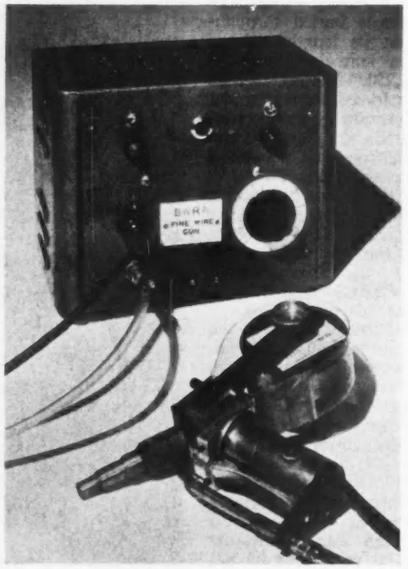
In the course of developing the process, research was also carried out with a view to producing thin chromium sheet by the new technique. By a method akin to the "lost wax" technique, but using a sheet steel pattern it was found possible to produce chromium sheet of similar dimensions and finish to the pattern and of a purity as high as 96 per cent. The possible applications for this class of chromium sheet are now being investigated.

Gas-Shielded Fine Wire Welding Gun

WE illustrate a fine wire welding gun which was developed some time ago at the laboratories of the British Welding Research Association, Abington Hall, Cambridge, to investigate the feasibility of using the inert gas consumable electrode process for welding thin materials. This gun is suitable for welding wires of 0·030in, 0·015in or 0·010in diameter. It can be used with feed speeds from 1000in per minute down to the usable minimum of 350in per minute. When fitted with a 1 lb reel of wire it has a total weight of only 3 lb 8 oz.

A small motor which forms an integral part of the body and handle assembly of the gun drives the feed rolls for the wire which is mounted on a spool carried on a spindle in arms at the rear. The electrode wire is fed through a contact tube where the welding current is picked up, the wire having a clearance of about 0·005in in the bore of the copper tube. This tube, which is enclosed in a barrel and supported in it by a split collet, has at its free end replaceable screw-on gas nozzles. The drive to the feed rolls is transmitted through an arrangement of gearing which enables the barrel to be swung through 90 deg. on the handle; this adjustment affords barrel settings to facilitate welding in difficult positions. The trigger of the gun actuates a relay in a separate control box and this relay serves to energise the feed roll motor, a solenoid valve controlling the argon supply and a welding current contactor.

A composite tube is used to transmit power for welding and argon shielding gas to the gun.



Equipment for argon-shielded, consumable electrode, fine wire welding

It comprises a bare stranded copper power lead enclosed in a loose-fitting polythene tube through which the argon passes. As the maximum current for the size of wire used in welding is under 150A, the torch only needs to be air cooled.

The control box of the equipment contains a transformer/rectifier for supplying d.c. to operate the wire feed drive motor and a potentiometer for feed speed control. It also includes the solenoid-operated argon valve. An inching button for the wire feed and an argon purge switch are mounted on the panel of the box.

British Railways Electrification Conference

SIR BRIAN ROBERTSON, Chairman of the British Transport Commission, has invited the British Electrical and Allied Manufacturers' Association and the Locomotive and Allied Manufacturers' Association of Great Britain to join the Commission in staging an Electrification Conference and Exhibition in London next year. The Conference will take place from October 3 to 7, 1960, the sessions being held in the Great Hall of the Institution of Civil Engineers, and an exhibition with the theme of "Developments in A.C. Electrification, including the Supply Aspect," will be held concurrently on the British Railways site at Battersea. It will be the aim of both events to demonstrate the progress made with the installation of a.c. railway electrification under the British Railways modernisation programme, and it is proposed that conference papers should be read on three of the five days to allow time for delegates to visit the London Midland Region Manchester–Crewe and the Eastern Region electrification schemes. It is expected that approximately 300 overseas delegates will attend the conference. Invitations will be sent to all railways known to be electrifying or considering electrifying their railways and to other appropriate overseas buyers.

Oil Burner Sequence Controller

A CADMIUM-SULPHIDE photo-resistive cell providing direct operation of the miniature contactor controlling the oil supply is incorporated as flame-detector in a new fully automatic oil burner sequence controller announced by Photoelectronics (M.O.M.), Ltd., Oldfields Trading Estate, Oldfields Road, Sutton, Surrey. Normally the photocell is mounted in the blast tube of the burner, but housings are available for mounting on the front plate of the boiler if required. The cell operates on a.c. at the full mains voltage and is capable of passing currents up to about 30mA. Comprehensive safety circuits are provided, including a safeguard against false energisation of the contactor caused by the photocell having been removed for servicing the burner and left exposed to light. In these circumstances, or should the cell leads short circuit, an external warning bell is operated. It is also arranged that should the time clock controlling the heating cut off the supply while the synchronous motor timer in the unit is moving through the oil period, subsequent restoration of the supply will cause the motor to complete the cycle without bringing on the oil, and then start a new cycle at the correct time. Two purge periods have been incorporated, and an additional cam and switch can be provided to energise the solenoid valve for a predetermined period for automatic purging of the oil line when using heavy oil burners. The unit is contained in a pressed steel box measuring 8in by 4in by 4in and operates on 200/250V a.c., single-phase, 50 c/s, with a power consumption of 15W.

Turbine Relighting

IN our issue of February 8, 1957, page 213, it was related that a platinum-alloy glow plug had been provided by K.L.G. to relight the Bristol "Proteus" engine when a flame-out was caused by accummulations of ice entering the compressor. It was stated in a paper by C. E. G. Payne and G. F. Pitts to the Aircraft Ice Protection Conference held by D. Napier and Son, Ltd., at Luton Airport on June 9 last, that initial trials were made with plugs of "Sintox," which were abandoned since surface cracking after a few hours flying suggested that their life would be short. Since the K.L.G. plugs were adopted, development has continued, and it has now been found that a plug consisting of a ⅛in diameter cylinder of silicon carbide gives equally good service at a greatly reduced cost. This plain plug performs as well as, if not better than, platinum alloy plugs of complicated shapes, sparking plugs, and plugs heated electrically or by fuel feed to keep them hot enough at 30,000ft without incurring intolerable heat fluxes at take-off.

Vibratory Metal-Part-Finishing Machine

We are informed by Roto-Finish, Ltd., Mark Road, Hemel Hempstead, Herts, that the firm is now developing a range of metal finishing machines in which a vibratory motion replaces the conventional rotary action. This new principle was developed by the American Roto-Finish Company and we illustrate a 7 cubic foot capacity machine made by that company.

It is stated that the new system is four to six times faster than the rotary barrelling method

Vibratory machine for finishing metal parts

in which the abrasive action takes place in a sliding zone several inches deep extending the width of the rotating cylinder. Beneath the zone little or no relative motion takes place between the components and the processing media, the mass being carried around in a position of repose until the point is reached where it commences to slide. With the vibratory system the container holding the mass of work and chips is subjected to a three-way vibration which produces an overall rotary motion of the whole mass, and, at the same time, movement of the individual chips in random directions. As the movement zone extends throughout the entire mass, work is accomplished much more rapidly.

With the conventional rotary system the amount of work that could be done on internal surfaces is limited, but the vibratory system, with its three-way movement of the chips, ensures that the media flows through cavities at the same rate as over external surfaces. The machines have an open head container so that visual control of progress and process is possible, and they are adaptable for continuous flow processing where the parts emerge at the same speed at which they enter.

Line-Earth Loop Tester

The line-earth loop tester illustrated here is a new addition to the "Megger" series of instruments designed and made by Evershed and Vignoles, Ltd., Chiswick, London, W.4. It represents a new approach to the testing of circuits which will carry current to earth in the event of a fault. With this instrument the full mains potential is applied to pass a current of approximately 20A through a circuit consisting of the live conductor, the earth continuity conductor and the earth return path; the instrument passes the test current through the fault path and the indicating instrument employed may be calibrated directly in terms of the resistance of this path.

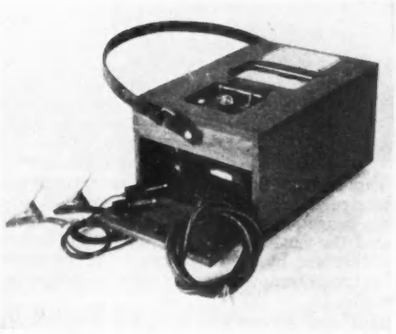
This kind of test is called for in Regulation 507 of the I.E.E. Wiring Rules, but the majority of instruments designed for this purpose pass a current through a loop consisting of the neutral conductor, the earth continuity conductor and the earth return path. In measuring this current its magnitude may be interpreted in terms of the resistance of this loop. There are, however, objections to this method as the neutral conductor may be shared by other consumers and may therefore already carry a current. Therefore there may be a significant voltage drop across the neutral and as, in most of the testers described, the testing voltage is fairly low (say 20V to 40V), even a relatively small voltage drop in the neutral conductor may well result in considerable error in the final measurement.

In the Evershed line-earth loop tester, a ballistic meter is used as, clearly, the test current must be of limited duration; the ballistic meter will, however, maintain the reading after the current pulse has declined. A synchronous motor, energised through a push-button switch, is used to drive a contactor which connects a 10 ohm resistor from the live conductor to earth for a period of 5 cycles (i.e. 0·1 second). The current during this period will be of a value determined by the 10 ohm resistor plus the actual resistance of the fault loop in series with the 10 ohm resistor. The meter, which is connected in parallel with the resistor, can thus be calibrated in terms of the loop.

The motor is automatically switched off when the current pulse has been passed, and the instrument has means for the resetting of the pointer of the ballistic meter after completion of the test.

Because of the importance of the mains potential on the calibration of the instrument a mains voltage selector has been included in the instrument and it has to be adjusted to the mains voltage of the locality where tests are to be undertaken. This procedure is adequate where the mains voltage is known precisely, but an auxiliary voltmeter can be supplied integrally with the instrument; it may become essential where tests have to be carried out at the end of a long feeder. To ensure the correct polarity of, say, a three-pin socket an indicator lights up when the polarity is correct.

The resistance measurement obtained on the ballistic instrument may, of course, be related



In the "Megger" line-earth loop tester the full mains voltage is applied to pass a current of about 20A through the live conductor, the earth continuity conductor and the earth fault

to the required fuse ratings for the circuit under test. A table is affixed to the instrument with which the readings on the meter may be instantaneously translated into fuse ratings or circuit breaker settings.

Apart from the earth loop tests, the instrument can be used for determining the actual earthing efficiency of an electrical appliance. Jack plugs are fitted to the instrument which modify the test circuit in such a manner as to connect the metal frame of the appliance and the attached earth conductor of the mains lead of the appliance, so that the resistance of the path can be measured. In this test, again the instrument imposes the same load conditions on the earthing circuit which might occur in the event of faulty insulation in any section of the appliance. Three-phase circuits can also be tested, a switch being provided for convenient switching from single to three phase.

50 MeV Proton Linear Accelerator

The 50 MeV (million electron volt) proton linear accelerator at the Rutherford High Energy Laboratory, Harwell, went into operation at full energy last month. It is the first particle accelerator of the National Institute for Research in Nuclear Science. When the accelerator is in full operation it is expected that it will have a proton beam intensity many times greater than that of other accelerators of its kind.

In the linear accelerator protons are accelerated by applying a radio-frequency voltage across successive gaps along a path in an evacuated chamber. In this particular accelerator there are three such chambers which accelerate the protons successively to energies of 10, 30 and 50 MeV; each structure is a cavity resonating at a frequency of 202·5 Mc/s. The machine works in short pulses because of the very high radio-frequency power required. One advantage of the linear accelerator over circular machines is that the energy can be increased by the addition of further units if desired; extraction of the proton beam is also simpler.

The main parts of the accelerator were designed and constructed for the Atomic Energy Authority by Metropolitan-Vickers Electrical Company, Ltd., in collaboration with physicists and engineers from the Atomic Energy Research Establishment, who also carried out basic development work on the accelerating structures, and were responsible for the other parts of the machine.

Thermocouple Trip Amplifier

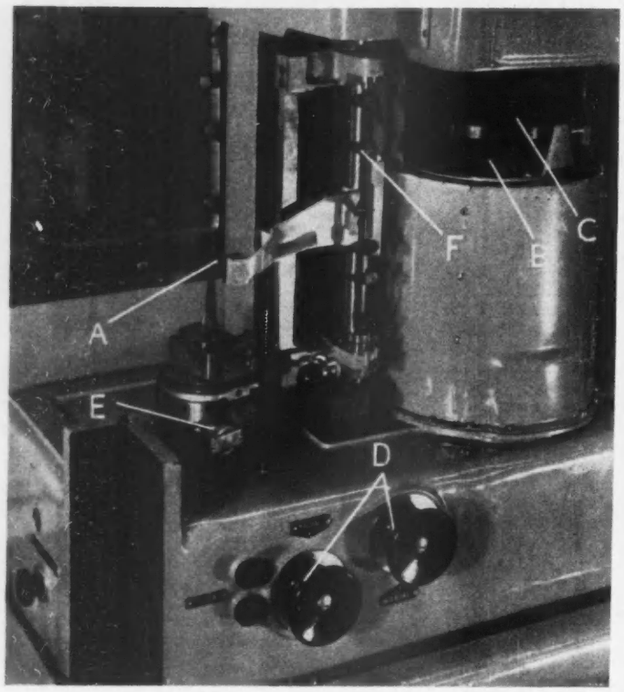
A fully-transistorised thermocouple trip amplifier has been developed by Ekco Electronics, Ltd., Southend-on-Sea, Essex, primarily for use in nuclear reactor installations, but also for many industrial applications. The "N642" amplifier covers the range 0–250 deg. Cent., but this can be extended to 1000 deg. Cent. to special order. Trip level is set by means of a ten-turn helical potentiometer with a dial directly calibrated in temperature. A "low-margin" warning is also provided for releasing a second internal relay at any point within the meter range. A trip will also occur with an open-circuit thermocouple.

The meter has two scales, one calibrated directly in temperature and showing up to 100 per cent of the ambient-to-trip range according to requirements, and the other showing the temperature deviation below the trip setting. Either reading is selected by a switch. Lamp indications of "warning," "trip," and "mains on" are given by coloured lights on the front panel. The control switches and setting scale are protected by a hinged "Perspex" panel. The shape of the meter, as seen in the accompanying illustration, is such that four instruments can be installed side by side in a frame which fits a standard 19in rack. An a.c. mains supply of 110–120V or 200–250V, 45–60 c/s is required, and a mains tapping panel is provided for the necessary adjustments within this range. Mains-frequency interference is rejected by a 700 c/s transistor chopper preceding the amplifier and detector. The instrument is normally used with a chromel-alumel thermocouple.

Trip amplifier with direct temperature and trip margin indications for use with thermocouples

Contour and Profile Projector

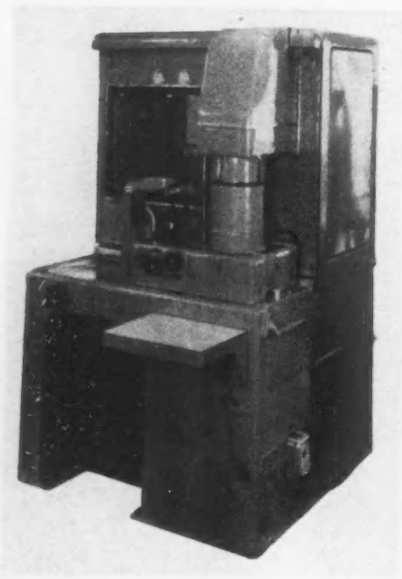
A NEW equipment for the accurate and rapid inspection of aircraft engine compressor and turbine blades has been designed by D. Napier and Son, Ltd., in conjunction with Optical Measuring Tools, Ltd., of Maidenhead, the latter company being responsible for devising the optical system and for the construction of the projector. The instrument, which can be seen in the accompanying illustration, is equally well adapted for the precise checking of profiles and contours of other components within its capacity. This projector does not use the method hitherto adopted to determine the contour of the shape of a component being inspected, by means of a feeler attached to the top slide of a compound table and in contact with the stationary workpiece. In this former system movements of the feeler are reproduced by a lens or a graticule positioned on the same slide. On the new projector, the work is rotated and a feeler mounted on the extremity of a pivot arm is held in contact with it. Movements of the feeler are recorded by a lens attached to the opposite end of the arm. This method has an advantage in that abrupt changes of contour, such as when the feeler is travelling round either the leading or trailing edge of a turbine blade, can be determined without difficulty.



Turbine blade contour being checked on projector

One of our illustrations shows the instrument in use for the inspection of a turbine blade. It has a pivoted arm carrying at one extremity a disc feeler *A* which is located against the contour of the blade. At the opposite end of the arm, on the other side of the pivot, is mounted an objective lens, with its optical axis an equal distance from the pivot axis to that between the centre of the feeler disc and the pivot axis. To explore the contour, the holder supporting the blade is rotated, causing the pivoted arm to swing in an arc. The projection lens swings in a corresponding arc over a graticule *B* carrying the correct form of the cross section being inspected, the graticule being connected to the blade holder so that it rotates through the same angle as the holder. A fixed collimation lens situated above the projection lens projects the image of the rotating graticule on to the screen which carries a semi-circular fiducial mark with appropriate tolerance zones. As the blade is rotated, the 20 × image of the graticule blade form rotates round the semi-circle on the screen and errors are displayed by the deviations of the graticule form image from the fiducial circle markings on the screen.

With this instrument it is also possible to analyse the errors of a blade cross section into (*a*) lean or displacement of the blade form from the stacking line, (*b*) twist or rotation of the blade section, and (*c*) form errors. The lean or displacement errors are measured by use of a glass plate *C* situated between the form graticule and the objective lens. This plate can be tilted about two horizontal axes at right angles to one another, these axes bearing a constant relationship to the blade-form graticule since the glass plate and the axes rotate with the graticule. By manipulation of two plate tilting controls *D* the image of the blade form can be moved to the required position and the vector components of the total displacement read off in one-thousandths of an inch from circular scales engraved on the control wheels. Errors of twist are removed and measured by rotating the workholder itself, the amount of rotation being read from a micrometer drum *E*. When the errors of twist and lean have been eliminated from the blade form on the screen image the contour check may be carried out, and to check different cross sections on the same workpiece the feeler arm is moved up or down its locating pillar. A series of preset adjustable stops *F* on the pillar are used to locate each position of the feeler arm. The maximum cross section which can be checked on the instrument, which has a 24in by 16in screen, is 2×6in, and the maximum length of workpiece which can be inspected is 6in.



Projector for checking profiles on turbine blades and similar components

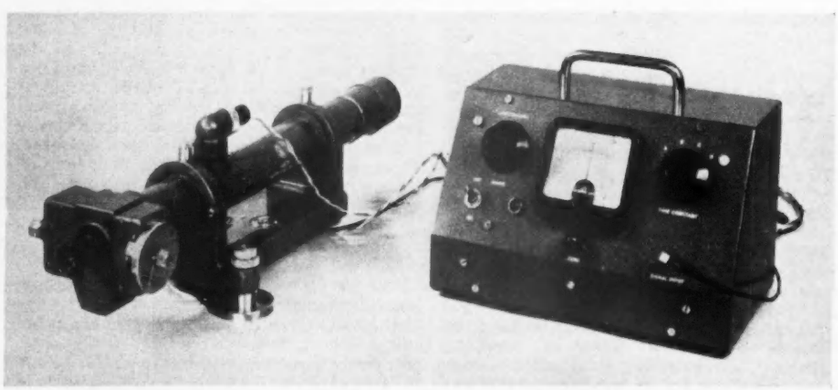
Photoelectric Autocollimator

AN autocollimator incorporating a photocell and detector device for providing readings on a meter located in any position convenient for the operator has been introduced by Hilger and Watts, Ltd., 98, St. Pancras Way, Camden Road, London, N.W.1. As seen in the illustration, the telescope and base units are similar to the Watts "Microptic" autocollimator, but the micrometer eyepiece embodies a photo-electric detector consisting of a vibrating slit and a Hilger Schwarz photocell. A centre-zero indicating meter, incorporated in a separate unit which also contains the associated electronic equipment, can be located at a point remote from the autocollimator.

The instrument is first set up visually and the vibrating slit is then positioned, by rotation of the micrometer drum, so that it oscillates symmetrically about the reflected image of the target wire. In this position the meter indicates zero. Subsequent left or right displacement of the image of the target wire is indicated by a corresponding deflection on the meter. This displacement can be read direct from the meter scale, but for precise accuracy the meter is reset to zero by the micrometer and the displacement is read on the micrometer drum.

The instrument is mains operated. Sensitivity and damping controls, and an on/off switch are located in the remote unit. The maker states that most existing "Microptic" autocollimators can be fitted with a suitable eyepiece for conversion to a photo-electric instrument.

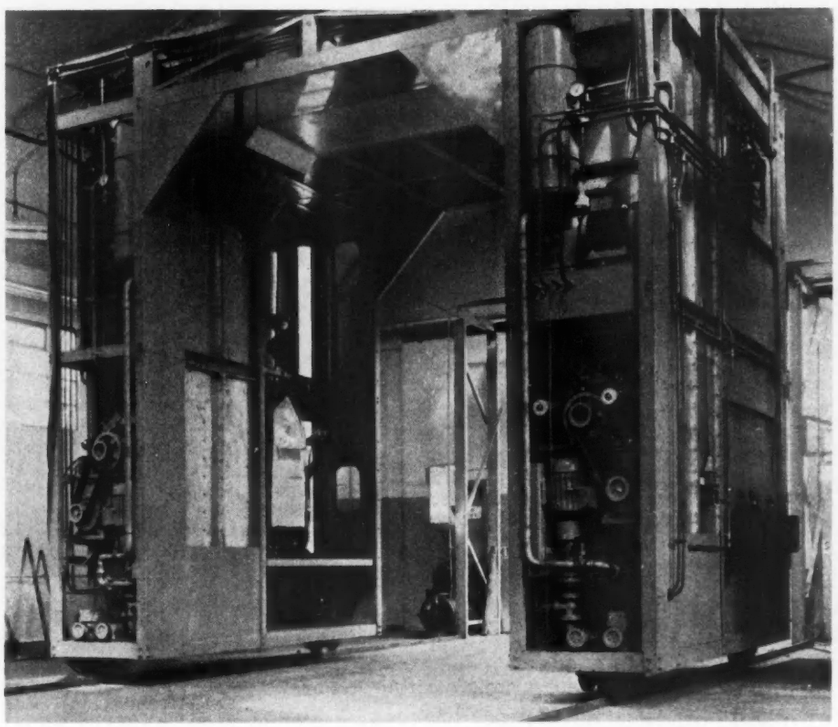
It is also announced that the range of Hilger and Watts autocollimators has been extended by a small, lightweight instrument known as the "Minidekkor," designed for the workshop and tool room, where applications include the checking of micrometer faces, set squares, vee blocks, small castings and tapers. The instrument can also be used for checking the location of moving slides and spindles. Overall length of the "Minidekkor" is 6in and the diameter of the telescope tube is 1in.



Autocollimator with remote electronic indicator

Travelling Paint Spraying Booth

A PHOTOGRAPH which we reproduce on this page shows clearly the construction of a travelling spray booth which has been developed by Aerograph-De Vilbiss Company, Ltd., 47, Holborn Viaduct, London, E.C.1, for the painting of rolling stock and locomotives. This arch-shaped booth is designed to straddle a vehicle and travel backwards and forwards under its own power whilst painters on adjustable platforms in the sides of the booth spray the vehicle's sides. The side members of the booth incorporate equipment for filtering, washing and exhausting the air from the painting area. As the booth is traversed along its rails, it takes its power supply from an overhead rail through a pick-up arm at the top.



Travelling spray booth for painting rolling stock and locomotives. The wire guards at each side have been removed to show details of the equipment

The booth is some 12ft 6in long, 17ft 6in wide and 16ft 6in high, and it can be traversed at speeds up to 25ft per minute along its rails. The 7ft wide compartments in which the painters stand on each side have platform floors which can be adjusted to any required height through compressed air operated lifting gear. Hinged steel platform extensions can be lowered from the painters' floors to enable the ends of a vehicle to be sprayed.

Air for operating the platform lifts and the spray guns is supplied at 100 lb per square inch from a two-cylinder, single-stage, air-cooled compressor set in each side of the booth. Each air washing equipment is complete with an exhaust fan, water supply tank, pump, drain sump, strainer, intake strainer screens, &c. During spraying the exhaust fans draw the air and paint overspray through high-pressure water sprays in the air wash chambers. The cleaned air is discharged through ducts at the top into an overhead duct fitted in the building roof above the centre line of the booth. A series of pivoted louvres fitted along the underside of the fixed duct are progressively opened by cams on the top of the booth as it travels along. Air is delivered into the operators' compartments through glass fibre filter boxes by input fans situated in the roof of the booth.

An automatic fire extinguishing system installed comes into effect at any temperature above the setting of fusible bulbs fitted in the booth. Fusing of any of these bulbs cuts out an electric switch which stops the exhaust fans and causes baffle plates to drop over the exhaust openings adjoining the painters' platforms. Carbon dioxide stored in pressure cylinders is then released to blanket the spraying area in the booth.

The makers point out that the installation of this design of booth does not call for any extensive alteration in an existing building, and it occupies an area of only 216 square feet, as compared with the average area of 2000 square feet for a fixed booth. It largely eliminates the fire hazards involved in lacquer and enamel spraying in the conventional down draught booth, and enables effective supervision of painting operations.

Hydrostatic Transmission

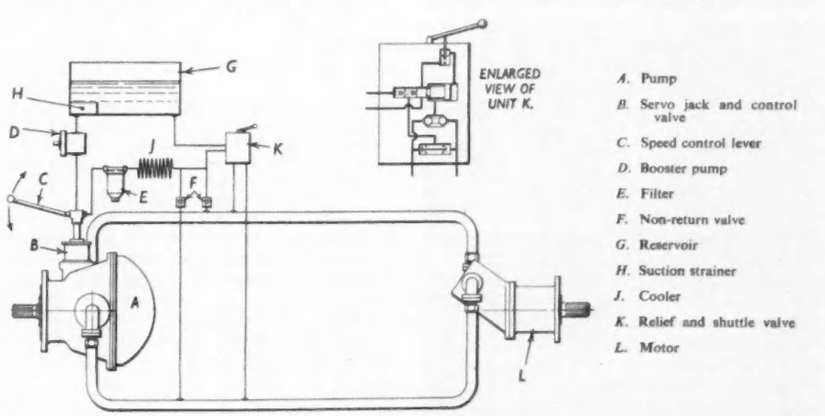
IN our issues of December 20, 1957, and December 19, 1958, some account was given of a system of hydrostatic transmission in the development of which Dowty Hydraulic Units, Ltd., Ashchurch, Glos, has been engaged for some time. This transmission fitted to a Fordson "Major" tractor was first demonstrated last December. Now, the transmission, or Dowty "Transmatic" drive as it is to be called, is being produced at Ashchurch and recently we watched trials of some industrial vehicles to which it has been applied in addition to the tractor. They include a Marshall diesel road roller and a Ruston and Hornsby narrow gauge diesel locomotive.

The Dowty "Transmatic" drive utilises a variable displacement hydraulic pump, driven by the prime mover and capable of full flow in either direction, and a fixed displacement motor which is normally coupled to a final drive reduction gear. Pipe connections between these two components complete the main hydraulic circuit, but there is an additional low-pressure circuit for pressurising whichever side of the pump represents the inlet. In the primary circuit an axial-piston tilting-head pump is employed, the angle of the pumping elements being altered in order to adjust the stroke of the pistons. The motor utilises identical rotating parts but is set at the maximum angle of 35 deg. The accompanying diagram shows the complete transmission circuit. The low-pressure system consists of a Dowty gear pump, Micronic filter, the circuit control valves and a small reservoir.

The angle of the primary pump is adjusted by a servo-jack, only a very light hand load being required to adjust the pump output; a mechanical linkage is normally employed between the servo and the driver's control. To protect the system against sudden overloads, a high-pressure relief valve is incorporated, but to prevent a pressure build-up and vehicle movement should the engine be started with the driver's control away from neutral, there is provision for unloading the relief valve. An interesting point about the "Transmatic" drive is the braking characteristic. When the pump angle is reduced, the roles of pump and motor are reversed, the pump motoring the prime mover; the effect is similar to the use of a low gear, the engine acting as the brake. We are informed that very effective braking is obtained and, when the pump angle is at zero, the drive is locked hydraulically. The following table sets out the basic data of the "Transmatic" drive (designated Type 240).

Pump and motor displacement	12·41 cubic inches
Number of cylinders	10
Rated pump maximum input speed ...	2000 r.p.m.
Maximum continuous operating pressure	4000 lb per square inch
Maximum flow	89·5 g.p.m.
Pump swash angle	35 deg.
Motor speeds available	0–2000 r.p.m. in either direction
Maximum torque at rated pressure ...	625 lb ft

The makers says that the rated performance is based on a torque multiplication of 4 : 1 and an input to the pump of 60 b.h.p. at 2000 r.p.m. Within this rating the overall efficiency does not fall below 80 per cent, the optimum being approximately 90 per cent at half motor speed. At 60 b.h.p. input, the motor offers full torque from zero to 400 r.p.m. Between 400 and 2000 r.p.m. torque varies inversely with speed in order to maintain a constant horsepower.



Hydrostatic transmission circuit

Industrial and Labour Notes

Strike Settlement

Agreement was reached on August 12 at a meeting between employers and unions at the Ministry of Labour on terms for settlement of the strike which had begun on July 20 at the Cowley works of Morris Motors, Ltd., over the dismissal of a chief shop steward of the Transport and General Workers Union. Eleven unions were involved in the dispute. The strike was resumed when the works reopened after the annual holiday fortnight on August 10, but on that day the Chief Industrial Commissioner of the Ministry of Labour, Mr. P. St. John Wilson, invited both sides to informal talks. These opened on August 11, and the settlement was announced the following evening. It was agreed that the shop steward concerned should be transferred to the Pressed Steel Company, Ltd., on terms and conditions similar to those of his employment at Morris Motors, and it is open to the unions to take the question of his dismissal through the industry's procedure for the avoidance of disputes or to go to some other form of adjudication.

Graduated Pension Scheme

Under the National Insurance Act, 1959, which received the Royal Assent on July 9, a measure of graduated contributions and retirement pensions related to employees' earnings is introduced into National Insurance, but the Act allows those in occupational pension schemes which satisfy certain conditions to be contracted out. It is planned to begin the collection of graduated contributions in April, 1961. The first group of draft regulations for contracting out were published on August 11. They comprise the draft National Insurance (Non-Participation - Certificates) Regulations, 1959 (price 6d.); the draft National Insurance (Non-Participation—Appeals and References) Regulations, 1959 (price 4d.); and the draft National Insurance (Non-Participation —Benefits and Schemes) Regulations, 1959 (price 3d.); and can be obtained from H.M. Stationery Office or through any bookseller. The Regulations provide for the formal appointment of a Registrar of Non-Participating Employments to decide applications for contracting-out certificates, and questions arising on them. To allow time for consultation, employers intending to apply for a contracting-out certificate will be required to give at least one month's notice to the employees concerned, and the Registrar can defer issue of a certificate to allow time for further discussion between an employer and his employees. There is right of appeal to an adjudicator of high legal standing, to be appointed by the Lord Chancellor, against any decision of the Registrar; and a right of appeal from decisions of the Adjudicator to the High Court or Court of Session on a point of law. If an employer's application to contract out is successful, and the Registrar grants a certificate of non-participation, graduated contributions will not be paid for the employees covered by the certificate. Instead, the present flat-rate contributions will continue to be paid for flat-rate benefits (including the present flat-rate retirement pensions). The National Insurance Advisory Committee has announced that it will consider representations on the draft regulations received by it not later than September 8, 1959. Representations should be made in writing and should be sent to the Secretary, National Insurance Advisory Committee, 10, John Adam Street, London, W.C.2.

Engineering Statistics

Production in the engineering and electrical goods industries in May is stated by the Board of Trade to have shown a slight rise compared with April, in spite of the incidence of the Whitsun holidays, and was 6 to 7 per cent greater than in May, 1958, which also included the Whitsun holidays. In the three months March, April and May, which included the Easter and Whitsun holidays in both years, production was 2 per cent greater than in the corresponding months of 1958; the increase in production of consumer goods would account for the whole of this increase, and there is still no evidence of a general increase in production of industrial plant and machinery. The volume of orders on hand is estimated to have increased slightly during May, with export orders on hand showing an increase, after falling in every month since March, 1958. Home market orders on hand were unchanged at the end-March level. These figures confirm the impression of an improvement in new orders received. Information so far available for June indicates little change from May in the level of production, after allowance is made for the effect of the Whitsun holidays; this would leave the index about 2 per cent above the level of June, 1958.

National Industrial Safety Campaign

As a result of the recent dispute in the printing industry, the Industrial Safety Division of the Royal Society for the Prevention of Accidents has postponed the national safety campaign, planned for the week beginning September 28, until the week beginning November 23, 1959. This year's campaign, which will demonstrate to industrial workers the correct methods of lifting and moving goods and materials, involves the production of many thousands of posters, leaflets, pamphlets and other items of publicity material. Production of the bulk of this material was arrested by the seven-week dispute and the Society made the decision to postpone the campaign knowing that specimens of the publicity material available would not be ready in time for industry to assess its requirements and obtain supplies in time for a decisive and co-ordinated national effort at the end of September.

United Kingdom Trade

Provisional figures of United Kingdom trade in July issued by the Board of Trade show that the rise in both exports and imports in the second quarter of 1959 continued. United Kingdom exports in July were £287·8 million, £36,000,000 more than in June and 5½ per cent above the monthly average for the first half of the year. Imports were £353 million, £21,000,000 more than in June and 10 per cent above the monthly average for the first half of the year. Re-exports were £9·3 million. The excess of imports c.i.f. over exports and re-exports f.o.b. was £55·9 million, £14,000,000 less than in June but nearly £19,000,000 more than the monthly average for the first half of the year. Exports to North America in July totalled £51·6 million, £6·7 million more than in June and an increase of 13 per cent above the monthly average for the first half of the year. The exports of £31·6 million to the U.S.A. were nearly £2,000,000 more than in June and 7 per cent above the monthly average for the first six months of this year. Shipments to Canada, at £20,000,000, were nearly £5,000,000 more than in June and compare with a monthly average of £16·3 million in the first half of 1959.

Industrial Disputes

The Ministry of Labour has recently completed a detailed survey of stoppages of work in 1958 on account of industrial disputes. The number of work stoppages through disputes which were in progress last year in the United Kingdom was 2639, compared with 2859 in 1957; about 524,000 workpeople were involved and the aggregate number of working days lost was 3,462,000, compared with 8,412,000 working days lost in 1957. The largest stoppage of work last year, judged by the number of workers involved and the number of days lost, was that of 49,300 London Transport bus drivers, conductors and garage staff. It caused an aggregate loss of 1,604,000 working days.

Industrial Production

Reviewing the economy at mid-year in its August issue, the Treasury's *Bulletin for Industry* states that expansion is clearly under way, and against a background of stable prices and a strong external position. Seasonally adjusted figures for industrial production rose in the first quarter and again in the second and this expansion has apparently been more broadly based than in the rise last autumn. Car production in April reached record levels and in the second quarter was 16 per cent above a year earlier. Commercial vehicle output also rose sharply. Output of engineering and electrical goods as a whole was substantially higher in May than a year earlier, even allowing for the effect of the Whitsun holiday. There were also improvements over a wide range of industrial materials. Production and consumption of steel, output of general chemicals, paint, dyestuff and detergents, deliveries of imported softwood, and cotton textile output were all substantially higher in May than a year earlier. Coal output, however, has continued depressed. A marked rise in output per man is shown in the industries covered by the index of production. In the first quarter the gain on a year earlier was about 4 per cent and provisional estimates for the second quarter suggest a similar rise. In the advance of exports, engineering goods have led the way. Comparing the second quarter with the first, they were up 12 per cent (including notable rises in cars and chassis and in aircraft and aero engines) compared with 7½ per cent for shipments of chemicals, 4½ per cent for textiles (including wool tops) and 3½ per cent for metals. Civil employment by the end of June had risen by 223,000 to a total only slightly lower than in June, 1958.

5th International Congress on Internal Combustion Engines

THE Congrès International des Machines à Combustion (CIMAC), Paris, is a federation comprising the national organisations of internal combustion manufacturers in eleven European countries, in the United States of America and in Japan. Founded in 1950 with the object of promoting the international exchange of technical and scientific knowledge in this particular field of engineering, the CIMAC has in the past years arranged meetings at Paris, Milan, the Hague and Zürich to discuss various subject matters selected from the field of internal combustion engines and gas turbines. This year's conference took place at Wiesbaden (Germany) from June 14 to 19, and dealt exclusively with current problems of diesel engines and gas turbines up to 1500 h.p. The discussions, presented simultaneously in English, French and German to two study groups in parallel arranged sessions, were well attended, and social meetings as well as visits to well-known German engine factories gave the members of the congress an excellent opportunity of comparing notes and exchanging ideas of mutual interest.

Among the thirty-five papers presented to the congress there were some notable contributions to such general questions as the combustion of the fuel spray in an oxygen atmosphere, the flame spread in the combustion space and the criteria of cylinder design based on heat transfer. Several papers dealt with the turbo-charging of diesel engines and with the constructional problems arising from the increased mechanical stresses on engine components and accessories. Other topical subjects were the prospect of the small and medium-sized gas turbine for road, rail and ship propulsion and as industrial prime mover, and the use of free-piston generators in conjunction with turbines. In view of the considerable number of papers and additional contributions presented in the various discussions, the following report only deals with papers having a wider general interest.

J. F. Alcock and R. Watts of Ricardo and Co., Shoreham-by-Sea, presenting a paper on "The Combustion Process in High-Speed Diesel Engines," described combustion research on a special two-stroke engine, the valve-less cylinder head of which allowed almost complete freedom of combustion chamber design. Using cylinder heads fitted with transparent "Perspex" windows and a high-speed cine-camera, they investigated in detail the mechanism of ignition and the spread of the combustion, indicator diagrams being taken simultaneously.

Work so far has been on two combustion systems, the conventional four-spray direct injection with swirl, and the Ricardo "Comet" swirl chamber. Some other chambers are now being studied, and it is hoped that a truer understanding of what happens inside a combustion chamber may well prove a useful tool to the designer, who can exert some control on it by varying the shape of the chamber and the inclination of the jet.

Fig. 1, in diagrammatic presentation, shows the cylinder head of the test engine used for studying a direct-injection chamber, formed by a semi-toroidal cup in the piston crown. Fig. 2 shows six frames illustrating part of the combustion sequence; the frames, which start at 3·5 deg. before T.D.C. and end 7 deg. after T.D.C., are not consecutive, but are selected to show interesting phases. They clearly show the incidence of the ignition and the propagation of the flame.

Some 400 combustion cycles have been photographed this way; the variables studied included chamber shape, injection details, and fuel quality. "Dummy runs" with injection of non-inflammable liquid showed the later stages of fuel distribution which are masked by flame in the combustion experiments.

Although work is still in progress it has already been shown that current views on diesel combustion need considerable modification. For instance: (1) the fuel jet strikes the wall, and the resulting "splash" can spread some distance along the wall, playing an important part in the fuel-air distribution; (2) a substantial proportion of the spray is vaporised before the ignition; (3) the ignition occurs in small, separate nuclei which coalesce later—in direct-injection engines the point of initial ignition can vary considerably from cycle to cycle without any noticeable effect on the engine performance or on the indicator diagram; (4) the nuclei never occur in the visible spray,

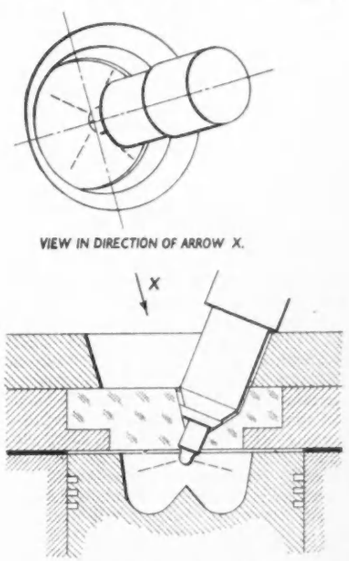


Fig. 1—Cylinder head of a test engine with transparent cover for taking high-speed photographs

but usually near it or in the "wall splash"—presumably the fuel in the ignition zone is so completely vaporised as to be invisible; (5) in a divided-chamber engine the combustion process differs from the preconceived theory, namely that of a precombustion in the cell, followed by an expulsion of the burning gases into the cylinder. The ignition normally occurs just on the cell side of the throat, and the flame spreads at about the same rate within the cell and through the throat into the main chamber.

A considerable number of papers dealt with the experience gained in the development of high-pressure turbo-charging of diesel engines, and such related questions as the design of engine components capable of standing up to increased thermal and mechanical stresses.

Dr. K. Zimmer, of M.A.N., Augsburg, in his paper "Output and Strain Relations, Demonstrated on an Exhaust-Turbocharged High-Speed Diesel Engine," pointed out that the output of pressure-charged engines is limited by the thermal and mechanical loading of the individual components. Based on comprehensive research data, he explained how different factors, such as speed, fuel consumption, valve overlap and the temperature of the charge air, influence the exhaust temperature as well as the temperature of the cylinder walls, the piston and the exhaust valves, and, further, how the charging air pressure affects the pressure in the cylinder. He maintained that by careful attention to detail design, in particular to the shape and the timing of the valves, the cooling of the injector and the piston crown and, further, to a sufficient rigidity of the crankcase and the running gear, most of the stresses can be kept within safe limits. Essential is an effective cooling of the air charge, for which purpose the air cooler has to be fitted with a water circuit separate from that of the engine, so as to provide a water temperature at the entrance of not appreciably more than about 50 deg. Cent. Dr. Zimmer mentioned as an example of the advantages of a modern supercharged diesel engine a vee-twelve-cylinder rail traction engine of 180mm bore and 210mm stroke, with two turbo-charger units, having an output of 1500 h.p. at 1500 r.p.m. This engine (Fig. 3) has a charge pressure of 906mm Hg. and an air inlet temperature of 66 deg. Cent., and is running very satisfactorily at a brake mean effective pressure of 14 kg per square centimetre. Tests have shown that by more intensive cooling of the air charge, outputs up to 1700 h.p. can be maintained at continuous rating. The unit weight of this engine with all accessories in relation to an output of 1500 h.p., amounted to only 2·65 kg per horsepower.

Dr. E. Küchler, of Daimler-Benz A.G., Stuttgart, in his paper on "The Marginal Performance of Turbo-Super-Charged Precombustion-Chamber Engines," maintained that high-speed diesel engines with single-stage turbo-chargers, which, at their maximum speed, could generate charging pressure up to 3 atmospheres absolute, may be operated safely at a brake mean effective pressure up to about 18 kg per square centimetre

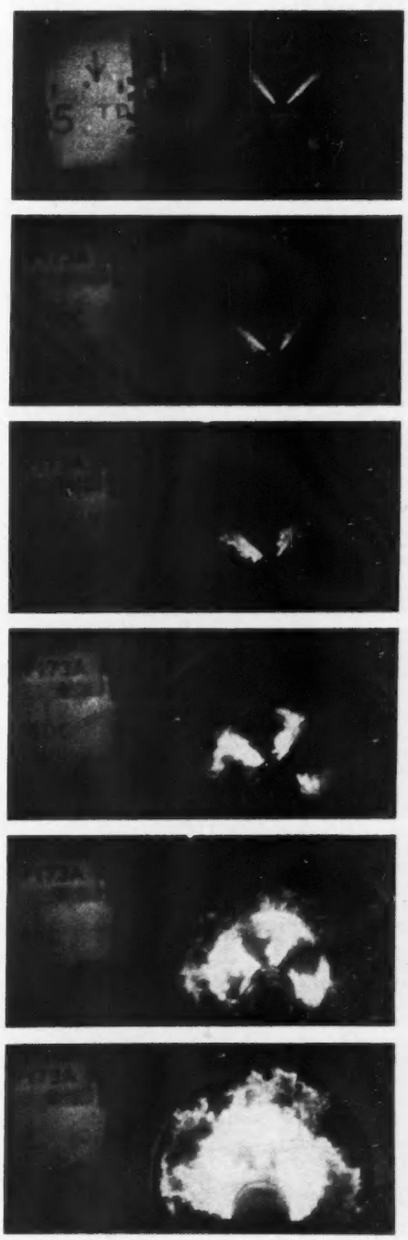


Fig. 2—Direct injection; flame spread in combustion chamber during ten degrees of crank angle

without any excessive thermal stresses. This value, however, should not be exceeded as, with the present materials available and with a peripheral speed of 350m to 400m per second, turbine blades could not stand up to exhaust temperatures of more than 650 deg. Cent. According to his experience, the engine itself at such a temperature is not yet thermally stressed to its limits, whereas the gas turbine is the weakest link in the chain of output-limiting factors. The speaker gave a detailed report on the interdependence of exhaust temperatures, charge pressures, excess air ratios and combustion pressures, based on tests with three engine groups run with different degrees of supercharging. He expounded his statements by graphs and charts which, he hoped, might help the designer in determining the mechanical and thermal stresses when developing a new engine of a given output limit.

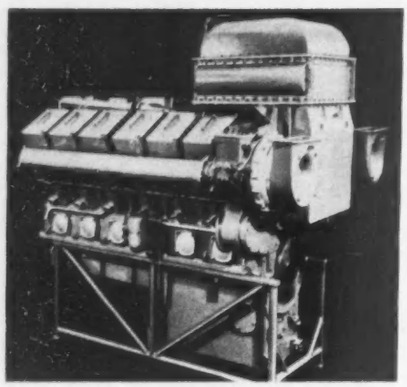


Fig. 3—1500 h.p. vee twelve-cylinder diesel engine with two turbo-chargers

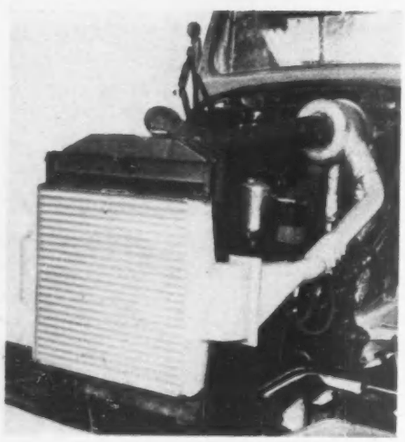


Fig. 4—Arrangement of charge-air cooler in front of the radiator

The trend of increasing the specific output of diesel engines by supercharging, hitherto mainly confined to medium and large low-speed engines, has lately become more and more noticeable at higher speeds and in smaller cylinder sizes. Small turbo-chargers are already being manufactured on lines approaching mass production, and it becomes desirable to examine the possible limitations of their application. A. Larborn and J. Stahlblad, of A. B. Bolve, Göteborg (Sweden), reported on their "Experiments with High-Speed Diesel Engines with Special Torque Requirements." A direct-injection, single-cylinder engine has been used to investigate the variations in piston temperature, firing pressure, and combustion efficiency at different degrees of supercharge. It could be shown that with charge cooling the increase in piston temperature over the normally aspirated engine is rather small, even at pressure ratios of 2·2 : 1, and it can be entirely compensated for by a simple oil jet cooling. Tests with a differential-driven positive displacement compressor showed that this arrangement adapts itself well to the engine requirements over a fairly wide speed range. In tests with a 6·12-litre engine with charge cooling, approximately double the output was obtained over the entire speed range with favourable fuel consumption.

In turbo-charging a 9·6-litre engine, a 45 per cent increase in brake mean effective pressure was obtained. When charge cooling was included in the tests, the output could be increased by 90 per cent, compared to a normally aspirated engine. In accordance with the experience gained with single-cylinder tests, it was shown that at high-pressure supercharge the ring groove temperature can still be kept below the maximum permissible level if charge cooling is employed.

The possibility of using efficient charge cooling in road vehicles has often been described as unrealistic. From the experiments of the authors the contrary is true : in a standard diesel truck, originally equipped with the 9·6-litre normally aspirated engine, a charge cooler of suitable form was simply clamped on to the front of the normal radiator (Fig. 4). With this arrangement, a fairly large number of tests hours have been accumulated during high-pressure operation, and it seems that modern, robust production engines are quite capable of standing up to the higher stresses involved.

C. H. Bradbury, of Simms Motor Units, Ltd., London, also dealt with the question of "High-Pressure Turbo-Charging of Small Engines," i.e. those up to about 1·5-litre capacity per cylinder and running at speeds up to 2700 r.p.m. After reviewing present-day practice (employing turbo-chargers having pressure ratios of 1·5 to 1·7), he examined future possibilities in the light of cycle calculations involving pressure ratios up to 6 : 1, and quoted development tests to correlate his calculations. He also stressed the value of an efficient charge cooling.

G. A. Montgomerie and M. K. Forbes of Serck Radiators, Ltd., Birmingham, in their paper "Refrigeration of Charge Air for Diesel Engines" pointed out that in pressure-charged engines used for rail or road traction the air, when cooled at all, is ultimately cooled by atmospheric air ; the temperature of air entering the cylinder is necessarily above the ambient air temperature. Apart from any effect of the atmospheric pressure, the rated power output of any given engine is then governed by the ambient air temperature, the engine being progressively derated with increasing air temperature.

If a refrigerator is used to cool the charge, the rated output may be increased. For this purpose the compression type vapour-cycle refrigerator appears to be the most useful. By using it to cool the charge to as low a temperature as is practicable, after heat has been extracted from it by a conventional charge air-cooler, savings in overall bulk, cost and weight can be achieved

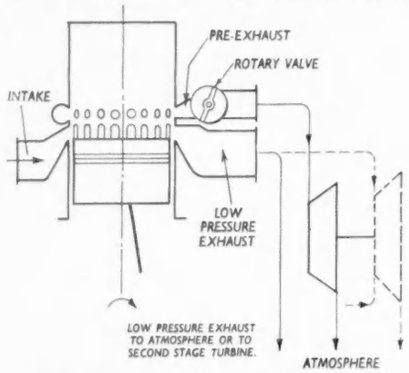


Fig. 6—Loop-scavenged two-stroke engine with pre-exhaust

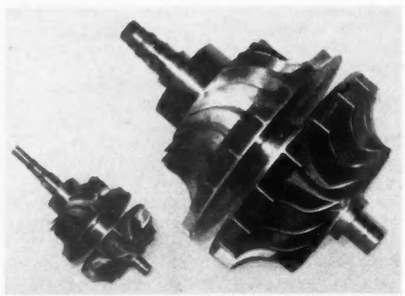


Fig. 7—Compressor turbine rotors of 110mm and 375mm diameter

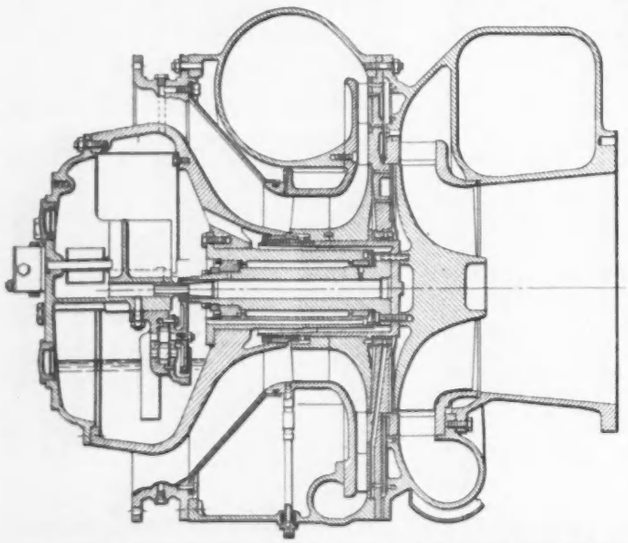
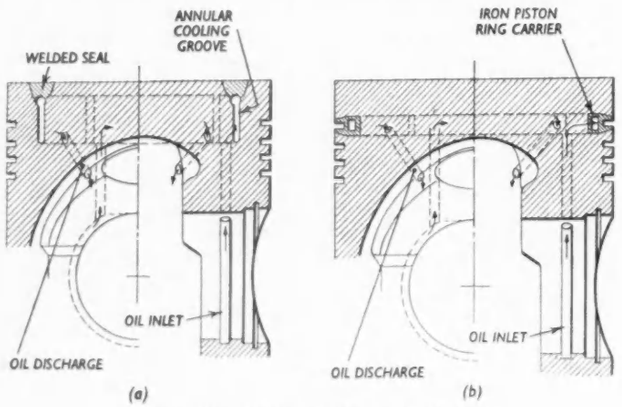


Fig. 5—Turbo-charger with horizontal shaft, showing the different design of the turbine casing for constant-flow (top) and for intermittent-flow operation (bottom)



(*a*) Forged piston with annular groove and welded seal.
(*b*) Cast piston with oil-cooled ring carrier. The oil is induced via the drilled connecting rod and the hollow gudgeon pin.

Fig. 8—Oil-cooled light-metal pistons

with a refrigerated engine in comparison with a larger non-refrigerated engine developing the same power.

"Diesel Exhaust Blowdown Energy" was the title of a paper contributed by Professor A. W. Hussmann of the Pennsylvania State University, U.S.A., and Dr. W. A. Pullman of the Rugby College of Engineering Technology. The paper described an investigation into methods of minimising a loss associated with conventional diesel cycles. This is the "blowdown" loss, caused by the fact that the gas in the cylinder at the moment of exhaust valve opening has not been fully expanded to the ambient or back pressure. The authors discussed the magnitude of the blowdown energy which theoretically could be utilised under various conditions, and also the physical systems which would be necessary to convert this energy into work.

The method described is to split the exhaust into two parts: the initial high-energy part or pre-exhaust is released from the cylinder by means of a controlled valve and passed to a turbo-charger, and the main exhaust is discharged into the atmosphere. Thus scavenging takes place against atmospheric pressure, reducing the work of the blower and leading to an increase in net output. Fig. 6, in diagrammatic form, shows the pre-exhaust system, applied to a loop-scavenging two-stroke engine. The authors, who have examined the pre-exhaust system in detail, both theoretically and experimentally, came to the conclusion that the amount of energy recovery is quite small and, with the mechanical complications involved, the application of this system to high-speed two-stroke engines cannot be recommended. It appears, however, that the pre-exhaust system in general might be applied to large slow-speed engines. In this range of application the problems of pre-exhaust valve timing are not so critical, and it can be expected that an appreciably larger percentage of the blowdown energy can be recovered than with the experimental high-speed engines used by the authors.

Dr. Pullman and Dr. R. V. Hughes, formerly of the English Electric Company, also dealt with the question of the "Influence of Turbo-charging on Component Design," describing experiments to improve duct and valve forms by means of Schlieren photography and by measuring the coefficient of discharge. They further showed how the peak cylinder pressure affects the connecting rod and bearing assembly and gave details of investigating the loading conditions with the use of photo-elastic and full-scale model techniques.

In "The Application of Centripetal Turbines in Connection with Centrifugal Compressors in the Manufacture of Gas Turbines," G. Oberländer of Klöckner-Humbold-Deutz A.G., Oberhausen, compared the properties of these turbines with those of axial-flow design. A comparison of such features as design and production, the flow characteristics, and of the obtainable adiabatic efficiencies of both turbine types indicate certain preferential applications for centripetal turbines, in particular their suitability as exhaust turbo-chargers and as gas turbines of small output and simple construction.

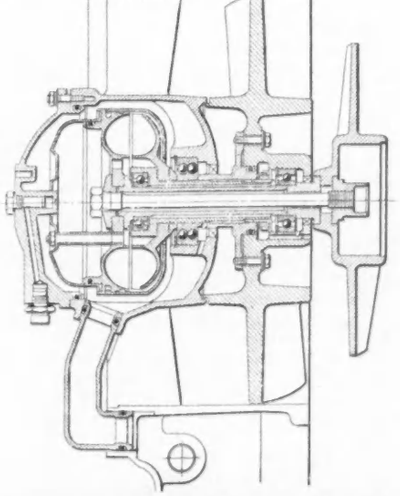


Fig. 9—Section through a variable-speed cooling fan coupling

The results of this study led to the development of a series of centripetal precision-cast turbine rotors which, together with centrifugal compressors, are being used in a corresponding series of turbo-chargers and also in some gas turbine types. Fig. 7 shows two rotors of 110mm and 375mm diameter. Fig. 5 is a sectional view of a turbo-charger showing the overhung rotors of the turbine and compressor attached to the horizontal shaft which is carried in two plain bearings. The spiral casing of the turbine and the diffuser casing of the compressor are separated by an annular channel through which cooling air, tapped from the diffuser, is circulated. The lubrication of the bearings is effected by means of a gear pump which draws the oil from an oil sump.

Dr. A. Meier of Mahle K.G., Stuttgart, in his paper on "Temperature and Fatigue Strength of Cooled and Uncooled Aluminium Alloy Diesel Engine Pistons" dealt with the influence of different systems of piston cooling on the life and the wear of the piston and the piston rings. A number of different oil-cooled pistons of either cast or forged light-metal alloys were examined, and the cooling effect was compared in a calorimeter with stationary heat flow; the comparison is based on data obtained with an equivalent uncooled piston. The experiments, for reason of convenience, were carried out with a piston of 112mm diameter, but they apply just as well to pistons of more than 180mm diameter, i.e. particularly those of supercharged engines, where the cooling of the piston crown by means of an oil jet from the small end of connecting rod is not practicable any more.

The author stated the results of his investigation as follows:

(1) Cooling the piston by means of a well defined cooling circuit lowers the temperature of the piston crown and of the top ring groove by about 50 deg. Cent.

(2) The cooling effect is not proportional to the quantity of cooling oil; increasing the amount of the cooling oil beyond an optimum point does not result in any equivalent increase in the cooling effect.

(3) Among the different cooling systems tested, an annular groove cut into the piston crown and subsequently closed by welding according to Fig. 8*a* is most effective; this is probably caused by the very short and unimpaired heat flow path between the piston crown and the oil in the cooling groove. The application of this cooling system to a forged piston results in the most favourable combination of fatigue strength, resistance to wear and ring sticking. This system, which also can be applied to cast pistons, is particularly suitable for high-pressure charged engines.

(4) The cooling of ring carriers (Fig. 8*b*), as can be expected, is adversely affected by the increased resistance to the heat flow of the cast iron insert. On the other hand, efforts to improve these conditions seem to be fully justified because of the favourable effect of the inserts on ring-groove wear.

The higher static and dynamic stresses imposed on engines by supercharging were the subject of various papers. C. Bourceau and A. Loupéré of Bureau Veritas, Paris, reported on an "Experimental Study of the Welded Frame of a Vee-engine." The frame under investigation comprised cast, stamped and rolled components and differed from other constructions in as far as the welded joints were subject to operational tensile stresses, and that the heat treatment after welding was carried out only on sub-assemblies. The general outline of the investigation was as follows: after determining the fatigue limits of various types of welded joints, a specimen of actual size, the length of which corresponded to one pair of cylinders, was mounted on a test machine and subjected to a tensile effort corresponding to the maximum static loading in service. The operational stresses were determined by strain gauges and by photo-elastic methods. Residual stresses due to casting, rolling and welding operations were examined by cutting out specimens and analysing the stresses by photo-elastic methods or by measuring the deformation with a mechanical extensometer. The information obtained permitted the study of improvements in design of parts and welded joints, such a design being adapted to the obtained isostatic curves. The investigation afforded valuable information with regard to the importance of the design of the individual components and to the welding sequences to the value of the fatigue stresses which the various welded joints can withstand, and to the residual stress relieving. It also proved that in this particular case the method of dispensing with the heat treatment of the whole frame was justified.

M. Yamamoto, of Niigata Engineering Company, Japan, discussed "The Relation Between Bending Rigidity of Crankcase and Crankshaft of High-Speed Diesel Engines." The author described experiments carried out with small-scale models and with full-size crankshafts and crankcases, to investigate the bending rigidity of these parts—with respect to a vertical axis at the cross section—under the influence of stresses, equivalent to those caused by the elastic deformations of the crankshaft of a high-speed engine. He developed a mathematical analysis to predict the maximum values of these stresses, occurring within a given speed range, for different crank arrangements and presented a method of determining the magnitude of the balance weights for the purpose of reducing the inner moments of an engine.

R. Müller of Klöckner-Humbold-Deutz A.G., Cologne, discussed "The Thermal Balance of Air-cooled Diesel Engines." The cooling equipment of air-cooled engines is generally laid out so as to provide a satisfactory cooling effect at full load and under normal working conditions. In consequence, at part loads and at temperatures below normal, overcooling occurs if there is a rigid transmission between the crankshaft and the cooling fan. Overcooling, however, means not only higher cylinder wear, but a poor utilisation of the air which is forced through the cooling system with a relatively high expenditure of power.

More favourable conditions are obtained by modifying the thermal equilibrium in such a way as to keep the temperatures within the cooling system essentially constant. The author demonstrated a system particularly suitable for air-cooled automotive engines which comprises a thermostat responsive to the outlet temperature of the cooling air and a variable-speed device between the fan and its drive. Fig. 9 shows a cross section of the fan arrangement with a hydraulic coupling interposed between the intake shaft and the cooling fan. The slip between the primary and the secondary impeller, and consequently the speed of the latter, can be controlled by a throttle valve which, responding to the thermostat, increases or reduces the oil flow through the coupling. Road tests have proved the beneficial effect of this system in reducing the power requirements of the fan and its noise level.

C. B. R. Feilden, of Ruston and Hornsby, Ltd., Lincoln, in his paper on "World-Wide Operating Experience with 750/1000kW Gas Turbines," pointed out that, in the power range up to 5000kW, the vast majority of industrial gas turbines are operating upon a simple open cycle, which, in most cases, is non-recuperative. Though such cycles can only offer thermal efficiencies of about 15 to 20 per cent, the total installed horsepower of gas turbines up to 5000kW now approaches 2,500,000. This substantial figure includes installations in certain well-defined categories of which the following are the most important:—

Base load power of mechanical drive applications in locations where fuel is cheap, for instance, in oilfields.

Base load applications where use can be made of the gas turbine's exhaust heat, either directly in a process or as steam raised in waste heat boilers.

Stand-by power plants, in some cases fully automatically controlled.

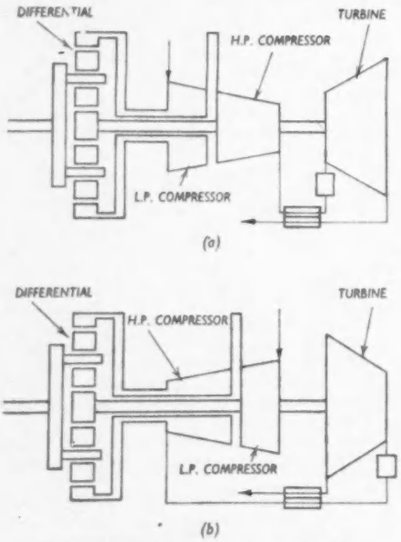
The author asserted that in none of the fifty-six

gas turbines built by his firm has there been a single compressor or turbine blade failure. Similarly, the performance of the mechanical parts of the turbine, including bearings, high-speed flexible couplings and other structural components which departed from previous practice have been trouble-free. Reporting about results of service experience, obtained with 750/1000kW gas turbines burning gaseous and vanadium-containing fuels, he described techniques developed for removing sticky deposits from the aerodynamic surfaces of axial and centrifugal compressors and turbines by liquid cleaning materials and by the use of non-adherent solid particles, for instance, ground walnut shells of about 0·4mm to 0·7mm particle size. By using appropriate cleaning methods it has been possible to obtain, on gas turbines operating on uncontaminated natural gas, non-stop runs of the order of 6000 hours and periods of more than 16,000 hours between major overhauls.

Discussing "Trends in the Development of Gas Turbines for Vehicle Propulsion," Dr. A. T. Bowden and Dr. W. Hryniszak, of C. A. Parsons and Co., Ltd., claimed that a gas turbine having a split compressor (instead of a split turbine), with the two compressor parts and the power transmitting shaft linked by a differential gear, overcomes the disadvantages of other designs with regard to positive and negative torque behaviour, reaction time to load charges and to low specific fuel consumption. The fact that such a turbine (Fig. 10) is undivided, allows the optimum design for this component, especially important in the case of a single-stage centripetal turbine, and permits adjustment of the gear ratio of the vehicle drive in accordance with the gas turbine performance.

Discussing the question of the heat exchanger, the authors advocate the regenerative in preference to the recuperative air preheater : although valve type regenerators with a fixed matrix and sleeve valves give the smallest mass-flow losses, the rotary type with an annular drum housing the matrix fits better into the design of an automotive gas turbine unit. The introduction of non-metallic materials such as ceramics, and the introduction of a multi-drum design, may reduce the parasitic weight, facilitate the ingress and egress of the two heat-exchanging gases, and eliminate the destructive effect of excess temperatures.

The possibility of reducing costs by mass production makes the recuperative plate type heat exchanger an attractive proposition. Such a heat exchanger can be subdivided into a number of similar self-contained elements and can be made at reasonable costs by mass production methods. Standardisation of heat exchangers will relieve firms engaged in developing automotive gas turbines from including the preheater in their programme, a situation very much the same as applies to the radiator for the indirectly cooled piston engine.



(*a*) High pressure compressor coupled with turbine; Low pressure compressor driven from differential
(*b*) Low pressure compressor coupled with turbine; High pressure compressor driven from differential

Fig. 10—Gas turbine unit with a split compressor

Dr. B. Eckert, of Daimler-Benz A.G., Stuttgart, speaking about the "Prospects for Gas Turbines up to 1500 H.P." drew attention to the fact that in the years after the second world war the future prospect of the small gas turbine has frequently been considered too favourably ; at present, the aspects are often judged as rather discouraging.

When critically examining the technical and economical problems of small gas turbines it appears that the reciprocating engine—in particular, the diesel engine—will probably keep its present field of application for some considerable time. However, there is reason to believe that the small gas turbine will find its use for a number of applications, and might eventually become a strong competitor of the diesel engine. Its particular advantage is the capacity of adapting itself well to the specific requirements in respect to the number of constructional elements and to a great variety of fuels. At the present state of the art, it is possible to build a simple and lightweight power plant with a relatively high fuel consumption, or to reduce the latter by additional components, especially by using a heat exchanger. There is little doubt that by intensive research and development the efficiency of compressor and turbine can be further increased ; new materials will allow the employment of higher compression ratios and consequently higher working temperatures, and more efficient heat exchangers, most probably of the regenerative type, should find an increased attention. To judge from the available evidence, it appears that, with regard to operational reliability and cost of maintenance, the gas turbine of to-day is already superior to the reciprocating engine.

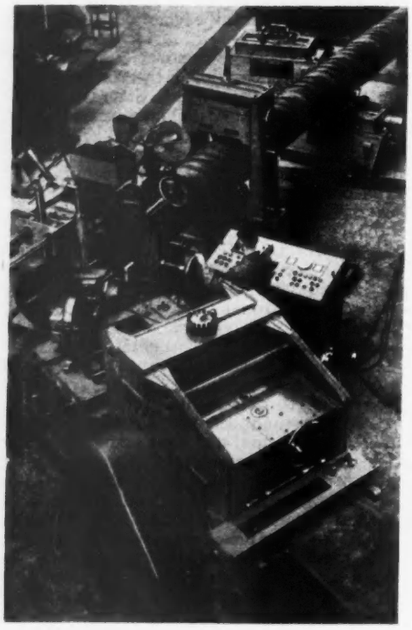
Professor S. J. Davies, of the Royal Military College of Science, Shrivenham, in his closing address, pointed out that the decision of the CIMAC to limit the subjects discussed at the congress to those appropriate to diesel engines and gas turbines developing powers of up to 1500 h.p. was a wise one, since by restricting the field under consideration the depth and unity of the papers has been in large measure ensured. He offered his congratulations to the CIMAC on the most valuable results of the congress, and thanked the German committee for their excellent work of preparing and organising the Weisbaden conference.

Spiral Tube Welding Machine

We have received details of an automatic welding machine for the production of spiral tubes designed and produced by Driam S.A., Hauptstrasse 19, Vaduz, Liechtenstein, and handled in this country by Vicsteels, Ltd., Craven House, 16, Northumberland Avenue, London, W.C.2. The machine is being built in a number of sizes covering a range of nominal diameters from ½in to 80in, with wall thicknesses varying from 22 S.W.G. (0·8mm) for the smallest machine to ⅝in (15mm) for the largest. The material used is strip ranging in widths from 2in to 96in, the width used depending on the size of tube which is to be made. The same width of strip can however be used to make a wide range of tube sizes. It is stated that an output of up to 15 tons per hour can be obtained, in the case of the largest and heaviest tubes. Taking as an example the "SRE900" model with a nominal range of 10in to 28in diameter, the output of the machine is quoted as 2·1 to 4·3 tons per hour, depending upon wall thickness.

Our accompanying illustration shows the arrangement. The material is used in coil form or in the form of flat plates butt-welded into continuous lengths. It is first passed through a set of five levelling rolls, followed by a pair of hydraulically-loaded feed rolls housed in the same frame. These are succeeded by a series of guide rolls to prevent buckling, as well as rolls which square the edges by cold rolling.

The material is then fed into the forming tool which forms it into a helix. As may be seen from our illustration, the forming tool comprises one or more blocks of steel presenting a semi-cylindrical cavity to the infeeding strip, the centre line of the tool and the line of feed



Automatic spiral pipe welding machine. The welding gap is automatically controlled by lateral movement of the pipe supports

including an angle greater than a right angle but somewhat less than the helix angle of the tube As a result, the strip touches the forming tool not over the whole surface but on one edge only, thereby considerably reducing friction. Friction is further diminished by the fact that contact with the forming tool is made over part of the circumference only, owing to the radius of the tool being larger than that of the tube. As a result the power requirements are small (2 h.p. to 8 h.p.).

The angle at which the forming tool is set is called the forming angle and is automatically adjusted during manufacture by means of slight rotations of the table. In this manner a constant diameter of the tube is maintained in spite of unavoidable variations in the strip widths.

Normally the machine is equipped for submerged arc ("Ellira") welding, but for thin gauges and special materials the "Argonarc" process is used. The double welding head, comprising the powder containers and two wire feed rolls, can be seen in the illustration. Two welds are run, the first from the inside at the point where the edges of successive turns first touch, the second from the outside with half a turn between the welds. The welded tube now passes through a guiding stand which contains an electronic device setting in operation a horizontal shift of the saddle rest, which, by moving to the right, tends to close the welding gap, or by moving to the left, tends to open it. This keeps the gap between consecutive turns closed, as required for correct welding.

The completed tube emerges from the machine continuously, and passes on to tube rests when it is cut to the required length. Ancillary equipment for cutting off, as well as for joining strip ends, can be supplied.

It is stated that the machine is suitable for the continuous production of pipe from hot or cold rolled steel of 24 to 33 tons per square inch, with naturally black edges or sheared edges. In addition any other weldable steel or non-ferrous alloy can be used. For a diameter of 40in the tolerance on diameter and ovality is given as +3mm, —0mm. Welding speed is of the order of 3ft to 5ft per minute, so that on average the output of a "SRE900" would be of the order of 4 tons per hour, or 5000 tons per annum for single shift operation. For pipes up to 30in., mobile installations can be supplied.

In addition to plain pipes, tubes with inside or outside fins or both can be made by folding the strip into "L" or "Z" shapes prior to forming the helix.

Fuel Fabrication at Argonne National Laboratories

BY OUR AMERICAN EDITOR

No. I

With the recent dedication of the fuel fabrication facility at the Argonne National Laboratory, Lemont, Illinois, an important milestone has been passed in the field of plutonium application in the American atomic energy programme. The new facility was built by the U.S. Atomic Energy Commission at a cost of some 4,000,000 *dollars and is devoted to the development of plutonium fuel element fabrication techniques and the manufacture of such elements for various American reactors. The special hazards associated with plutonium required the facility to be designed with various safety aspects, including extensive hood enclosures and a recirculating helium atmosphere system.*

A NEW facility, designed to advance man's knowledge of plutonium and to make significant contributions to the American nuclear power programme, was recently dedicated at the U.S. Atomic Energy Commission's Argonne National Laboratory, Lemont, Illinois. Known as the Fuel Fabrication Facility, this building and its plant (Figs. 1 to 4) are the culmination of more than three years of design work by Argonne staff members and two years of construction effort by contractors. The new facility is designed for developmental research on techniques for fabricating plutonium fuel elements. It also will be used to fabricate experimental plutonium fuel elements for several American nuclear reactors. The completion of this building is part of a long-range programme at Argonne. A fuels technology centre, designed to place even greater emphasis on metallurgical research, is now under construction at the Argonne site. When this facility is completed, many of the research efforts carried out there will receive practical application at the Fuel Fabrication Facility, since the latter is primarily a development unit for fuel fabrication methods.

Plutonium Development

Plutonium is a highly radioactive, toxic element. It is man-made in a nuclear reactor starting with uranium as a raw material. This relatively new chemical element is the first of the transuranium elements produced and isolated on a large scale. During the last two decades, research, development and production work on plutonium have been conducted in America by the University of California at Berkeley, the wartime Metallurgical Laboratory at the University of Chicago, the Argonne National Laboratory, the Clinton Laboratory in Tennessee (now the Oak Ridge National Laboratory), the Los Alamos Scientific Laboratory, and the A.E.C. works at Hanford, Washington, and at Savannah River, Georgia. It was in 1940 that the possibility of producing and using plutonium as a nuclear fuel was first suggested by Dr. Louis A. Turner, of Princeton University.

In 1940, Dr. Turner stated in an article prepared for the *Physical Review* that uranium^{239} would probably decay to form element 94^{239}, now known as plutonium. He further showed that it was likely that the nucleus of this element would be one in which fission would be highly probable. In an article submitted for publication in May, 1940, but withheld until 1946 by voluntary censorship then in effect, he predicted that the fission property of element 94^{239} offered a basis for an indirect method of securing energy from U^{238}, the stable isotope of uranium. In 1940, the nuclear physics group at the University of California began to use neutrons from its cyclotron for the production of plutonium, and to separate it from uranium and investigate its fission properties. In May, 1940, E. M. McMillan and P. H. Abelson isolated invisible quantities of the artificial element neptunium after bombarding uranium compounds in the Berkeley cyclotron. The sample was too small for the isolation of the daughter product (later found to be plutonium) to which neptunium decays. Later, in the winter of 1940–41, enough plutonium was prepared at Berkeley to enable G. T. Seaborg, A. C. Wahl and J. W. Kennedy to begin the study of its chemistry by following it through reactions by its radioactivity. By bombardment of several hundred pounds of uranyl nitrate with neutrons in the cyclotrons at Berkeley and at Washington University, St. Louis, sufficient quantities of the new element were obtained to permit the investigation on an ultra-microchemical scale of many of its properties.

By the end of 1942 about 500 microgrammes had been obtained in the form of pure plutonium salts. Work at Chicago began with this—the entire world's supply. Investigations into the chemistry of plutonium started at the University of Chicago in April, 1942, when a small group of chemists, many of whom had participated in the work on plutonium at the University of California in 1940, gathered in Chicago. The first work was done in the Kent Chemical Laboratory, the George Herbert Jones Laboratory and the west stands of the University's athletic field. The Metallurgical Laboratory at the University of Chicago was established by the U.S. War Department in 1942 as part of the major effort to develop nuclear weapons. In 1943 most of the research on plutonium was transferred to a temporary chemistry laboratory built on the University campus for the Metallurgical Laboratory.

Plutonium is not produced from an ore, as are most other metals, but must be made in a reactor. At the Clinton Laboratory, a pilot plant nuclear reactor for plutonium production started operating in late 1943. From uranium slugs exposed in the reactor the first microscopic quantities of plutonium were isolated in 1944 by a separation process which had been developed in Chicago on the basis of experiments using only microgramme amounts of the element. Hanford was then selected as the site on which to build large-scale facilities for plutonium production. On April 6, 1943, ground was broken for the Hanford construction camp in central Washington. At the peak of activity in 1944, this camp was a city of 60,000 inhabitants. Work was begun on the first of the Hanford plutonium production reactors in June, 1943; operation of the first pile began in September, 1944. Three reactors were constructed, together with the necessary facilities for processing and separating plutonium. Hanford continues to be the major source of plutonium in the United States to-day.

It has long been known that plutonium possesses favourable nuclear characteristics in a fast (unmoderated) neutron flux. Indeed, the nuclear situation is so favourable that such a reactor system, fuelled with plutonium and blanketed with a layer of U^{238}, will not only produce power but will also "breed" more plutonium in the blanket than is consumed in the core. Once sufficient plutonium has been accumulated to fuel such devices, the power system is not only self-sustaining but also self-expanding. It presents the rather attractive feature of a power system operating on the abundant isotope of uranium and with a constantly increasing inventory of fissionable plutonium. In view of these considerations, it would seem that by far the best utilisation of plutonium would be as fuel in a fast-neutron power-breeder reactor. The problem now becomes that of designing a suitable reactor system and of finding suitable materials of construction, the latter involving the development of plutonium-containing fuel elements.

In many respects plutonium turns out to be a very extraordinary metal. It has a relatively low melting point of 640 deg. Cent., not far different from that of aluminium or magnesium. In the temperature range from room temperature to the melting point, plutonium exists in no less than six crystal forms and thus undergoes five solid state transformations on heating or cooling to or from temperatures just below the melting point. Unusually large volume changes are associated with several of these solid state transformations. The densities of these various phases range from 19·8 for alpha plutonium at room temperature to 15·9 for delta plutonium at 320 deg. Cent. Several of these phases have very complex crystal structures and exhibit highly anisotropic behaviour, especially of thermal expansion coefficients. The average linear expansion coefficients are often large and in some cases negative. As a result of these large volume changes and the anisotropy of thermal expansion, plutonium undergoes considerable distortion when heated and cooled.

In view of these and other peculiarities in properties and behaviour, it was concluded that pure plutonium is essentially unusable as fuel in power producing reactors. Actually in such power producing reactors, none of the fissionable materials should be used in pure form, since the heat transfer surfaces available are inadequate to handle the energy generated in such concentrated fuels. The fuel must be spread out in some manner, and the most practical way is by dilution with some non-fissionable material—either fertile isotopes such as U^{238} or Th^{232} or inert materials such as aluminium. Under these conditions, the properties of the fuel resemble those of the diluent and the peculiarities of plutonium itself are largely eliminated.

Fuel Element Development

Usually, when a new material is developed to meet a specific requirement, it is possible to do the developmental work and perform pilot production operations in existing laboratory and plant facilities. The early development of the uranium fabrication techniques was carried out principally in steel and brass works. Because of radioactivity and toxicity, that approach has not been possible with plutonium. The fuel fabrication facility at the Argonne National Laboratory has been provided to fill the need for a fabrication process development laboratory, a pilot plant and a plant for the limited production of plutonium fuel elements. It is equipped with machinery of sufficient size, flexibility, variety and capacity to be useful for the manufacture of a wide variety of plutonium reactor fuel element loadings. Reactor research at the Argonne National Laboratory demands constantly changing fuel core designs. Each reactor operated by the Laboratory is basically a "test bed" for different kinds of fuel elements, since one of the research goals is to find out what kind of fuel is best for a given kind of a reactor. This means that the Laboratory cannot set up a standard assembly line to make reactor fuel. Successive fuel charges for Argonne reactors are often so different that completely different fabrication processes and metal working machinery are required for their manufacture. The materials, engineering requirements and designs are often so unconventional that entirely new fabrication processes and machinery must be developed. Hence, flexibility is an important feature of the new facility.

Fuel elements are designed as a joint venture by many specialists. The performance requirements and general design of the fuel may be

FUEL FABRICATION FACILITY AT ARGONNE NATIONAL LABORATORY

Fig. 1—Entrance of hooded fabrication area with application of dielectric sealing unit in foreground

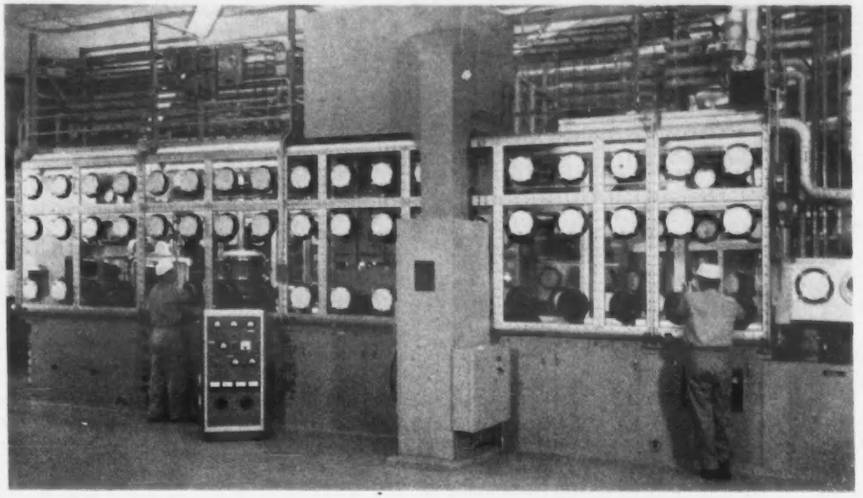


Fig. 2—Operators engaged at the pressing and powder metal working line of the hooded fabrication area

Fig. 3—Overall view of hooded fabrication area with rolling mill in left foreground and conveyor line on the right

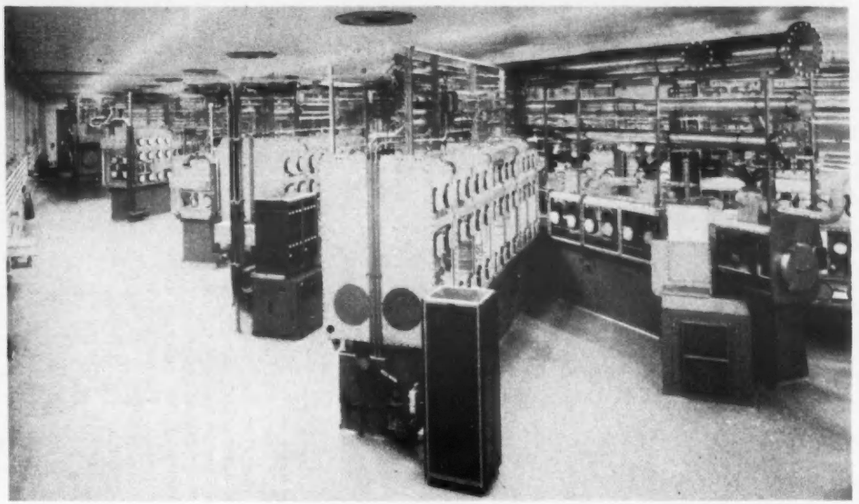


Fig. 4—Rear view of hooded fabrication area, showing five branch lines and extreme end of central conveyor line on the right

developed by reactor engineers. Metallurgists then specify or develop the alloys required to meet these requirements. Corrosion engineers are consulted regarding the choices of the jacket materials. Heat transfer specialists are concerned with the physical dimensions, thermal bonding and conductivity of the materials in the fuel element. Physicists are consulted for the nuclear effects of the alloying elements, bonding materials, jackets and general dimensional configurations, and they will specify the concentration or enrichment of the fissile isotope required. The fabricator is consulted as to the processes which may be employed to manufacture the fuel. Finally, the chemical engineers are consulted regarding the processes for the recovery of valuable materials left in the fuel after irradiation in the reactor. The fuel element fabricator will develop processes along the lines which best suit the specifications and requirements of the reactor core assembly. Often, fuel fabricated by several techniques is specified for test purposes.

The Experimental Breeder Reactor I (EBR–I) was first fuelled by rods which were rolled, swaged, heat treated and machined from unalloyed enriched uranium ingots. These rods were bonded into stainless steel jackets with a sodium-potassium eutectic alloy termed NaK. The second charge of fuel elements was made by centrifugal casting into precision moulds. The resulting fuel slugs were bonded into stainless steel jackets with NaK. A 2 per cent zirconium-uranium alloy was used in this charge to contribute radiation stability. The third fuel loading was manufactured by co-extruding uranium alloy with an exterior container of zirconium which formed the jacket. The bond in this case was a solid metallurgical bond.

The initial loading of the Experimental Breeder Reactor II (EBR–II) will consist of precision cast rods slightly more than $\frac{1}{4}$in in diameter. The alloy will be melted under vacuum and cast by inert gas pressure into heat-resistant glass moulds. The fuel will be heat treated directly in these moulds which will then be pulverised away from the castings. A complex alloy of uranium, zirconium, molybdenum, ruthenium, rhodium and palladium will be used to simulate the fission products which will be left in the fuel after later pyro-metallurgical reprocessing. A second EBR–II fuel charge will contain plutonium as part of the fissile material content. This process was developed to be adapted later to a remote-control fuel reprocessing and refabrication cycle at the reactor site in Idaho.

Several Argonne reactors employ plate fuel elements. Plates of this type are usually made by rolling the fuel element core material, which is then assembled into a jacket of the cladding material. This jacket is metallurgically bonded to the core by hot rolling, but it is also possible to braze the jacket on to the core. Various kinds of metal-jacketed ceramic and metal-ceramic core fuel elements have been developed which show considerable promise where high temperature operation is necessary or where resistance to aqueous corrosion must be provided. These fuel elements may be manufactured by any of a number of pelleting techniques and then bonded into metallic jackets by a metal heat transfer bond. They may be produced by co-extrusion of the core and jacket or by swaging a tubular jacket down upon a tamped oxide core.

The plutonium metallurgy programme at Argonne includes the following research and development facilities in existence or under construction.

(1) *F-Wing, Building* 200 (*Chemistry Building*).—This is a small physical metallurgical laboratory installed some years ago in three sections of the Chemistry Building. The laboratory contains a series of interconnected stainless steel glove boxes, most of which have a highly purified recirculated helium atmosphere. The containment of plutonium is complete, and there has been no detectable contamination of the personnel area. The laboratory contains equipment for working with only a few grammes of plutonium at a time. Some of the processes carried out are : melting, casting, rolling, pressing, extrusion, heat-treatment, cutting, mounting of samples, grinding, polishing, etching, photography and measurement of thermal conductivity.

(2) *Fuel Fabrication Facility, Building* 350.—This facility is fully described in this article.

(3) *Fuels Technology Centre, Building* 212 (*Under Construction*).—This building will be completed in 1960, and ground was broken in June, 1958. One of its primary purposes is to provide improved and considerably expanded facilities for the study of the physical metallurgy of plutonium and plutonium-containing materials. Equipment will be provided for carrying out, on a much larger scale, the plutonium metallurgy research now in process at Building 200. Other research, developmental and administrative functions of the Argonne Metallurgy Division also will be centred in this building.

(4) *Experimental Breeder Reactor II Reprocessing Plant*.—This plant is presently being built at the National Reactor Testing Station near Idaho Falls, Idaho, as part of the EBR–II reactor complex, scheduled for completion in 1961. It will be equipped for working with materials that produce both alpha and gamma radiation. The plant will be used for reprocessing of irradiated fuel core alloys from EBR–II. Experience gained will be of considerable value to reactor development and reprocessing technology. The plant will contain equipment for stripping the protective metal jacket from the irradiated fuel, for partially decontaminating the fuel, using a high-temperature reprocessing method, and for reconstituting, casting and jacketing new fuel pins. Thus, EBR–II will have a completely integrated fuel cycle. The plant will be plutonium tight, heavily shielded to attenuate gamma radiation and filled with an inert gas atmosphere. All operations will be by remote control.

Design of Fuel Fabrication Building

In designing "Building 350" (Fig. 5), where quantities of radioactive materials will be handled, the Argonne National Laboratory set goals of meeting specific requirements for processing nuclear fuel and, at the same time, assuring maximum safety to operating personnel and complete protection to the surrounding area against the spread of radioactivity. To accomplish these goals a building 245ft long and 72ft wide was specified, with a height 24ft above grade. This allows for a single room 165ft long and 72ft wide for fuel fabrication. The room is unobstructed by columns.

Portions of the building where radioactivity may be present are completely sealed to the outside. The main exterior walls are of monolithic reinforced concrete, sealed on the outside with a polyester plastic coating and painted on the inside with vinyl paint. All floors in areas where there is risk of radioactive contamination are covered with built-up glass fibre and polyester coating. Basement floors and floors bearing on the ground are sealed in the same manner. There are three working zones in the building, divided according to use and possible radiation hazard. These are an administration area, a technical area and a fabrication area. Each is completely sealed from the other areas with access between areas by means of an air lock.

The administration area consists of a lobby, offices, a counting room and clothing change rooms. This area is considered to have no more likelihood of contamination than any office or street in the immediate vicinity of a closely controlled radioactive materials laboratory. The area is air-conditioned and ventilated in the same manner as any uncontaminated office.

The technical area contains storage vaults for radioactive materials, a mechanical laboratory used for the maintenance or modification of equipment and for tooling, X-ray rooms, dark rooms, a health physics work room and a storage room. Contamination here would result only in case of a handling accident or of tracking contaminated material from the fabrication area. Three air locks with electrically interlocked doors isolate the technical area from other parts of the building.

The fabrication area is used for all work performed directly on radioactive materials or on reactor fuel pieces containing radioactive materials. While every effort is made to keep all space where personnel work free of contamination, the contamination risk is greatest in the fabrication area. All process equipment is assembled in the single fabrication room.

Reinforced concrete floors and roof decks are employed throughout the building except for the roof above the fabrication area. Here it was necessary to use a precast gypsum slab roof supported by 74ft steel trusses. A fire-retarding Vermiculite plaster ceiling was placed below the trusses. The walls separating the three major working zones and the interior walls in the basement of the building are of reinforced concrete ; the other walls are of concrete block masonry.

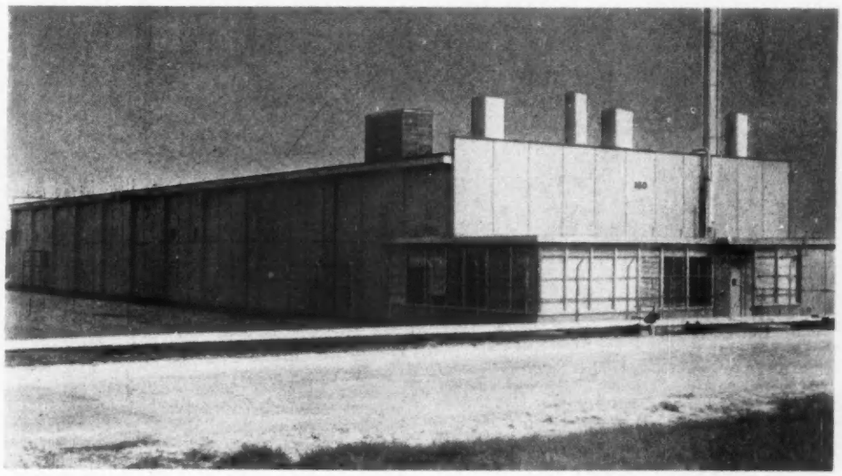


Fig. 5—Building 350, containing the new Fuel Fabrication Facility at the Argonne National Laboratory, is largely occupied by one room, 165ft × 72ft

The designers of the fuel fabrication building had to meet problems of keeping the floor exactly level in the fabrication room, where items of equipment weighing from a few pounds to nearly 50 tons are situated together in a system of gas-tight interconnected enclosures. This system of enclosures is 140ft long and 60ft wide. For heavy equipment within this system two areas stabilised to withstand a 3000 lb per square foot floor loading were provided on the north and south sides of the fabrication room by constructing 12in thick reinforced concrete slabs on compacted earth fill. The floor portions of the fabrication room over an excavated basement are built to withstand a floor loading of 300 lb per square foot.

(To be continued)

Personal and Business

Appointments

MR. M. H. LEY, A.M.I.E.E., has been appointed sales manager to Westool, Ltd.

MR. L. W. IBBOTSON has been appointed assistant general manager (modernisation), Western Region, British Railways.

MR. J. R. SIDEBOTHAM has joined Hunting-Clan Air Transport, Ltd., to take up the appointment of maintenance engineer.

W. E. SYKES, Ltd., announces the appointment of Mr. H. G. Jones, 3, Cluny Avenue, Failley, Clydebank, as its area representative for Scotland.

MR. M. ROBINSON has been appointed manager of the Bristol area office of Lancashire Dynamo Group in succession to Mr. E. H. Evans, M.I.E.E.

DR. W. F. HILTON is transferring from Sir W. G. Armstrong Whitworth Aircraft, Ltd., of Coventry, and joining Hawker Siddeley Aviation's Advanced Projects Group at Kingston-on-Thames.

THE ELECTRIC RESISTANCE FURNACE COMPANY, Ltd., announces that Mr. H. J. Tucker, southern area sales manager, has been appointed service manager. Mr. C. A. McNeill has joined the technical sales staff at the company's Midlands area office in Birmingham, and Mr. M. J. Parsons has joined the sales organisation at the head office in Weybridge, Surrey.

DR. N. B. DYSON has been appointed to the newly created position of manager, production planning and control for Monsanto Chemicals, Ltd. He has been succeeded as works manager at Newport by Mr. G. V. Taylor. Mr. K. H. Handy has been appointed works manager at the Ruabon, Denbighshire, factory, and Dr. E. W. Bodycote has been appointed works manager at Fawley.

MR. L. V. MOERE has been appointed to the executive board of the Taylor Woodrow Group. Mr. A. J. Hill has relinquished his position as managing director of Taylor Woodrow Construction, Ltd., but continues as chairman. Mr. T. Freakly and Mr. T. Reeves become joint managing directors of the Construction company. Mr. R. E. Aldred has been appointed managing director of Taylor Woodrow (Overseas), Ltd. Mr. John Ballinger, a director of Taylor Woodrow Construction, Ltd., has been appointed to the executive board of Taylor Woodrow for a period of twelve months.

Business Announcements

MACKNESS AND SHIPLEY, Consulting Engineers, Parliament Mansions, Abbey Orchard Street, London, S.W.1, announce that the senior partner, Mr. J. F. Shipley, M.I.E.E., has retired from active practice.

MARTONAIR, Ltd., Parkshot, Richmond, Surrey, has appointed Ernest Lowe and Co. (Pty.), Ltd., Cr. 5th Avenue, and 5th Street, Booysens Reserve, Johannesburg, as its agent for the Central African Federation and the Union of South Africa (except Port Elizabeth area).

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., announces that Nuclear Power Plant Company, Ltd., and the A.E.I.-John Thompson Nuclear Energy Company, Ltd., are to collaborate in nuclear matters. It is the immediate intention of the two companies to submit a joint tender for Dungeness power station, based on a common design and a similar procedure will in due course be followed for Sizewell power station.

THE CEMENT AND CONCRETE ASSOCIATION states that its Structures Research Department will now undertake model testing of concrete structures on a cost basis. Initially, the amount of work undertaken will be limited by existing facilities. Work which could more appropriately be carried out in a commercial testing house will not be undertaken. Inquiries about this aspect of the Association's work should be addressed to the deputy director of research and technical services, Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1.

DOUGLAS FRASER AND SONS, Ltd., Arbroath, and GIDDINGS AND LEWIS MACHINE TOOL COMPANY, of Fond du Lac, Wisconsin, U.S.A., announce the formation of a new British private company named Giddings and Lewis-Fraser, Ltd., having an authorised capital of £1,516,327. The purpose of this company is to acquire and continue the engineering business of Douglas Fraser and Sons, Ltd., and to manufacture Giddings and Lewis horizontal boring, drilling and milling machines. Fraser textile machinery activities will be conducted by the new company. To establish continuity of management with the new company, Mr. Norman Fraser has been appointed chairman, Mr. John G. Fraser managing director, and the other Fraser nominees to the board are Mr. John Macgregor and Mr. Charles N. Thomson. Directors nominated by the American company are Ralph J. Kraut, president of Giddings and Lewis Machine Tool Company ; Mr. William E. Rutz, Mr. Russell E. Hanson, and Mr. Morton R. Swift, who is vice-president Giddings and Lewis Foreign Operations, and resident in London.

Contracts

TAYLOR WOODROW (GHANA), Ltd., has been awarded a contract valued at £175,000 by the Ghana Government for part of the reconstruction of the ring road which goes round the north of Accra, involving the construction of a dual carriageway and road bridge.

STEWARTS AND LLOYDS, Ltd., has received an order from the Burmah Oil Company, Ltd. on behalf of Oil India Private, Ltd., for about 270 miles of 16in diameter steel pipe for an oil pipeline to be laid from the oilfields at Nahorkatiya in Upper Assam to an oil refinery which is to be built near Ganhati in Assam.

STANDARD TELEPHONES AND CABLES, Ltd., has received an order from the Russian Purchasing Authority for a quantity of airborne navigation equipment to be installed in Aeroflot TU104 jet aircraft flying the Moscow-London route. The equipment comprises I.L.S. (Instrument Landing System) and V.O.R. (Very High Frequency Omnidirectional Radio Range) installations for the aircraft.

THE WESTINGHOUSE BRAKE AND SIGNAL COMPANY, Ltd., has received an order through Electro-Chemical Engineering Company, Ltd., for Japan, which includes Westinghouse selenium water-cooled rectifiers with a total capacity of 60,000A. These are required for the electroplating of steel sheets with a thin zinc coating as a protection against surface deterioration, so that the final product, after pressing, folding, deep drawing or welding, presents a clean surface for painting.

DECCA RADAR, Ltd., has received an order from the Ministry of Communications in Venezuela for the installation of a " D.A.S.R.1 " surveillance radar at Maiqueta airport, Caracao. This equipment operates on the " S " band, but is stated to combine the coverage characteristics of these frequencies with the degree of immunity from weather and permanent echo interference which were required by the authorities and led to long-wavelength systems being specified in the invitations to tender.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd,, has been awarded a further contract for the supply and installation of television and sound broadcasting equipment by the Royal Board of Swedish Telecommunications. The equipment ordered on the present contract, costing approximately £292,000, includes twenty " BD321 " 5kW, frequency-modulated broadcasting transmitters, and sixteen television transmitters (four of 10kW, four of 4kW and eight of 5.0W vision output powers), with their associated sound transmitters and ancillary equipment.

THE DEMOLITION AND CONSTRUCTION COMPANY, Ltd., has been awarded a contract valued at £473,952 by the London County Council for the second stage of the River Wandle improvement scheme. The contract comprises regrading sections of river bed ; widening, deepening and culverting. Work on this part of the scheme will take about eighteen months to complete. These works, coupled with those being carried out by the Surrey County Council, will result in the capacity of the river being increased by one-third. The work is being carried out under the direction of the L.C.C.'s chief engineer.

LILLESHALL COMPANY, Ltd., Oakengates, Shropshire, has received a contract for the supply of the structural steel framework for a group of three twenty-storey office buildings which are to be erected at Lagos, Nigeria ; they are the first multi-storey structures to be built in any part of West Africa. The buildings are being erected for the National Property and Investment Company, Ltd., Lagos, at an estimated cost of over £1,000,000. The design is by Messrs. Hickson, Borys and Partners, architects, and Messrs. Oscar Faber and Partners, consulting engineers. The main contractor is Cappa and D'Alberto, Ltd., of Lagos.

HEENAN AND FROUDE, Ltd., has received a contract worth about £250,000 for a new refuse disposal works for the City of Birmingham. The plant will be capable of handling 300 tons of domestic refuse in sixteen hours and will include a double-line handling system with reception hoppers, rotary screens and dust hopper, salvage recovery plants with magnetic separators, metal and paper balers and two fully mechanised incinerator units. The plant is to be built at the city's Lifford depot. Heenan and Froude, Ltd., has also received a contract for six tyre test plants for Rumania, placed by a member of the Rustyfa Consortium.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION announces that contracts have been let for the following road works :

A 2-mile by-pass to take the Liverpool-Leeds-Hull trunk road, A.63, to the north of the Yorkshire village of North Ferriby, contractor Martin Cowley, Ltd. The scheme will cost £281,851 and has been prepared by the East Riding of Yorkshire County Council (county surveyor, Mr. W. L. Noel Bryce).

The 2¾-mile Biggleswade by-pass and the improvement of a further 2¼ miles of the existing trunk road (A.1) northwards, contractor Sydney Green and Sons, Ltd. The scheme, valued at £930,803, has been prepared by Bedfordshire County Council (county surveyor, Mr. S. W. Lynn).

The northern approach to the Dartford-Purfleet tunnel. A contract, valued at £333,997, has been placed with Edmund Nuttall, Sons and Co. (London), Ltd. It includes a viaduct, 330 yards long. The consulting engineers are Messrs. Mott, Hay and Anderson and Messrs. Coode and Partners.

AN agreement has been signed in Lagos between the Federal Government of Nigeria and Taylor Woodrow (Nigeria), Ltd., for the construction of a road bridge a mile long across the Niger, which will cost £5,250,000. Taylor Woodrow, it is stated, is arranging to finance the project. The bridge will be between Asaba, Western Region, and Onitsha, Eastern Region, the only other bridge across the Niger being for rail and road at Jebba in the Northern Region, about 400 miles away. It will have a steel superstructure comprising ten spans, each of 427ft, carried on reinforced concrete piers and abutments. There will be two carriageways and footpaths, totalling 68ft in width, and approach roads and bridge spans. Work is to start at the beginning of November and will take over four years to complete. The consulting engineers for the project are " NEDECO " (Netherlands Engineering Consultants) of The Hague, Holland. Taylor Woodrow (Nigeria), Ltd., has also been awarded a contract worth £250,000 for 47 miles of road works, under the development programme of the Western Region Government, Nigeria.

Miscellanea

ACCURATE TEMPERATURE CONTROLLER.—We are informed that the accuracy of the Winston-United Steels " M226 " temperature controller described on page 78 of our August 14 issue should have been quoted as greater than ±0·025 per cent at 1000 deg. Cent., and not 0·25 per cent, as stated in the information originally received.

HIGH SPEED PATROL BOATS.—It is announced by D. Napier and Son, Ltd., that all twelve of the " Nasty " class of high speed patrol boats, ordered by the Royal Norwegian Navy, the first of which has been launched recently, are each to be powered by two 3100 h.p., eighteen-cylinder mark T18-37K turbocharged Napier " Deltic " engines.

SHIPBUILDING STATISTICS.—The Shipbuilding Conference reports that, during the second quarter of the year, 29 ships of 44,000 tons gross were ordered, bringing the total for the first half of the year to 82 ships of 98,000 tons gross. The industry's order book at the end of June stood at 528 ships of 4,734,000 tons gross of which 823,000 tons gross, 17·4 per cent, was for foreign account.

FLEXIBLE STRAPPING MATERIAL.—A new form of strapping material has been produced by P. P. Payne and Sons, Ltd., of Nottingham, and the Package Sealing Company, Ltd., of Ealing, London, for securing and reinforcing fibreboard containers, cartons, paper sacks, &c., without damage. The material is made of virgin wood fibre twisted into yarns and bonded together to produce a strong, flexible, flat strapping. It can be applied under tension with a simple strapping tool, and joined by a seal of special design.

THE INFLUENCE OF PLASTICS IN BUILDING.—The Plastics Institute has arranged a two-day conference on the influence of plastics in building to be held at the headquarters of the Royal Institute of British Architects, 66, Portland Place, London, W.1, on Thursday and Friday, November 19 and 20, 1959. The conference is intended mainly for architects and constructional engineers. Admittance will be by ticket only.

ANTI-CORROSIVE PRIMER.—A new calcium plumbate primer for iron and steelwork, known as "Ledomide P," and made by Jenson and Nicholson, Ltd., of Stratford, London, is intended to replace red lead. It is stated to have excellent anti-corrosive properties, to flow better than red lead primer and produce a smoother film, whilst being lighter in weight and easier to handle. It dries within eighteen to twenty-four hours and has a creamy buff colour which is easily obliterated by subsequent coats of paint.

IMPROVED HIGH VOLTAGE RECTIFIER.—By the application of manufacturing techniques developed since the "A207" high-voltage, high-vacuum rectifier was introduced, English Electric Valve Company, Ltd., has improved the construction of this valve in several respects and has reduced its overall dimensions. The latest version is 8·15in long by 2·34in in diameter, as compared with 9·84in and 2·36in previously. This valve has a peak inverse voltage of 40kV and a mean anode current of 350mA. The selling price has also been reduced.

BOILERHOUSE ELEVATOR.—A chain and bucket elevator for handling fuels in boilerhouses now made by Bennis Combustion, Ltd., Little Hulton, Walkden, Manchester, is made in a series of standard components for quick and easy erection. Five basic units for an elevator include a feeding mechanism, a boot, a lower section, a head, and any necessary number of 8ft long mid-sections. Such elevators can handle up to 1½ tons of fuel an hour and they can be installed at any angle between 60 deg. and vertical.

SMALL AIR TURBINES.—A range of four small air turbines now being made by Turbomachines, Ltd., Station Road, Dorking, Surrey, covers power outputs from 0·5 h.p. to 1·9 h.p. at 25,000 r.p.m., with an air supply at 100 lb per square inch. These turbines weigh only 4¼ lb each and are available with collet and shafts or plain keyed shafts to suit particular applications. The firm is also making air turbine grinding units in two sizes—one with a free running speed of 110,000–120,000 r.p.m., and another, more powerful, with a speed of 85,000 to 90,000 r.p.m.

TRAILER-MOUNTED GENERATING SETS.—The National Gas and Oil Engine Company, Ltd., recently shipped four 500kW transportable generating sets to complete orders placed by the Argentine Government. Each set consists of a National mark R4AUU8 turbo-charged, eight-cylinder diesel engine directly coupled to a 500kW Brush alternator, Brush switchgear, and an air compressor set, &c., mounted on a skid pattern underbase. The complete assembly is secured to an independent sixteen-wheel trailer built by the British Trailer Company, Ltd.

VEHICLE PRODUCTION.—During the first three months of 1959 the United Kingdom was the world's largest producer of buses and second largest producer of goods vehicles, but only the fourth largest producer of cars. The *Monthly Statistical Review* of the Society of Motor Manufacturers and Traders, Ltd., for June, 1959, gives the following figures :—Cars : United States of America, 1,591,440 ; Western Germany, 347,913 ; France, 276,147 ; United Kingdom, 258,312. Goods vehicles : U.S.A., 307,372 ; U.K. 76,070. Buses : U.K. 3714 ; Western Germany, 1902.

CENTRALISED LEVEL CONTROL.—A development of the "Tektor Minor" level controller, which enables up to 150ft of coaxial cable to be used between probe and electronic unit, is announced by Fielden Electronics, Ltd., Wythenshawe, Manchester. The increase in interconnecting cable length enables the unit to be situated at ground level for ease of access or maintenance if required, or several units monitoring conditions in different parts of a plant may be housed in one case. This method of grouping reduces installation costs because only one mains supply cable need be run to the multiple unit.

PROTECTION OF INDUSTRIAL DESIGNS.—The President of the Board of Trade has appointed a committee under the chairmanhip of Mr. Kenneth Johnston, Q.C., "to consider and report whether any, and if so what, changes are desirable in the law relating to the protection of industrial designs. In framing their recommendations the committee should include consideration of the desirability of enabling United Kingdom designs to receive cheap and effective protection in other countries on the basis of reciprocity." Persons or organisations wishing to make suggestions or give evidence on matters within the terms of reference of the committee should communicate with the Joint Secretaries, The Designs Committee, The Patent Office, 25, Southampton Buildings, London, W.C.2.

HOT WATER CIRCULATOR.—A pump for small bore closed circuit central heating installations, known as the "Unipump 77," has been introduced by Copperad, Ltd., Colnbrook, Bucks. In this pump of "canned rotor" design the rotor runs in water and the bearings are water lubricated. It has no sealing glands and a filter is incorporated to prevent scale and dirt carried round the system entering the bearings. The pump is stated to be very quiet in running and its capacitor motor is designed for a power supply of 200/250V, 50 c/s, single phase. It can be fitted directly into a pipe line at any angle and requires no foundation or other fixing means when installed.

METAL RUBBER LAMINATE FOR SEALING.—An oil resistant sealing material comprising a bonded laminate of light alloy sheet and synthetic rubber, is being sold under the trade name "Hy-Clad" by British Geon, Ltd. This laminate combines the rigidity of metal with the oil resistance of synthetic rubber, enabling gaskets and washers made from it to be used repeatedly without damage. It can be sheared, drilled, punched or routed, using conventional equipment, and is available in standard sheets 12in, 18in and 24in square using 16 and 26 SWG light alloy sheet. The thickness of the rubber layer in the standard range is from 0·002in to 0·030in, and multi-ply and sandwich structures are made in addition to laminates consisting of one layer each of rubber and metal.

POST OFFICE TELEPHONE ANSWERING MACHINE.—It has been announced by the Postmaster-General that a telephone answering machine is to be introduced by the Post Office for connection to subscribers' telephone lines. A subscriber with this facility will be able to record an announcement of about sixteen seconds' duration before leaving the premises and this will be played back to any caller during his absence. Only messages which give the telephone number, the name of the subscriber and information as to when and where he can be contacted will be allowed. There will be an installation charge of £2 for the machine and a quarterly rental of £10. First supplies are expected in October. The machine will be in a plastic case to match the new two-tone grey-coloured telephone. It will measure 12in by 9in by 6in high.

EPOXY RESIN ADHESIVES.—A booklet entitled *How to Use Araldite Epoxy Resin Adhesives* is now available on request from CIBA (A.R.L.), Ltd., Duxford, Cambridge. It consists principally of two charts : the first shows the suitability of the various Araldite adhesives for a large number of adherents, and the second gives full details of the different adhesives. There are also brief descriptions of the treatments necessary for various materials—it is interesting to note that p.t.f.e. can be bonded after treatment with 1 per cent sodium in liquid ammonia, a shear strength of 500 lb to 700 lb per square inch being attained in a joint to aluminium—and advice on using the adhesive and designing the joint. The cover of the booklet is laminated with acetate film and the information confined to the inner pages, so that it should prove durable in the workshop.

OPERATIONAL RESEARCH.—A one-day conference on the subject "Operational Research at Work" has been organised jointly by the British Institute of Management and the Operational Research Society, and will be held at the Connaught Rooms, Great Queen Street, London, W.C.2, on Thursday, September 17. The object of this conference is to assist management in assessing the extent to which the techniques of operational research are applicable within industry. The following speakers will present papers :—Miss M. S. Munn on "The Study of Stock Control Problems" ; Mr. R. H. Collcutt on "Applying OR in the Steel Industry" ; Mr. H. R. W. Watkins on "The Operational Research Study of Transport and Distribution" ; Dr. K. Pennycuick, "Long-Range Policy Planning" ; and Mr. B. H. P. Rivett on "OR—Where Now ?" Further details of the conference can be obtained from the British Institute of Management, 80, Fetter Lane, London, E.C.4.

LONDON AIRPORT DEVELOPMENT.—Tenders have now been invited for the foundations and steelwork for a long-haul terminus at London Airport Central. The building will comprise a central two-storey block, a steel framework clad almost entirely with double glazing, for passenger processing, and two three-storey office blocks of reinforced concrete, with an enclosed court as a vehicle park. The baggage handling facilities will follow a straight line between front and back of the building. An open construction with movable partitions will allow the interior layout to be altered as required. Initially passengers will go to and from aircraft by coach, but the construction of "fingers" is intended. The transfer of the long-haul operators from London Airport North to the Central Area was recommended by the London Airport Development Committee under the chairmanship of Sir Eric Millbourn, C.M.G., and, as proposed by the committee, the building will face the south-west apron.

MERCHANT SHIPBUILDING RETURNS. — Lloyd's Register Shipbuilding Returns for the quarter ended June 30 record that the work in hand in Great Britain and Northern Ireland amounted to 280 ships of 2,033,745 tons and that during the quarter 58 ships of 189,431 tons were commenced, 69 ships of 363,581 tons were launched and 90 ships of 417,426 tons were completed. Oil tankers totalled 64 ships of 995,688 tons or 49 per cent of the total under construction. Work in hand abroad totalled 1172 ships of 7,708,291 tons and the commenced, launched and completed totals were respectively 374 ships of 1,841,795 tons, 396 ships of 1,877,243 tons and 398 ships of 1,917,895 tons. Oil tankers under construction amounted to 236 ships of 4,081, 208 tons or 53 per cent of the total tonnage. Throughout the world there were 1452 ships of 9,739,036 tons being built of which 300 ships of 5,076,893 tons, or 52.1 per cent, were oil tankers. Ships under construction throughout the world under the survey of Lloyd's Register amounted to 5,310,184 tons or 54.5 per cent of the total.

LIGHTWEIGHT LIFTING ENGINE.—The by-pass principle has been adopted by Bristol Siddeley Engines, Ltd., for the lift/thrust engine now projected, the BE 53. Whereas the ducted fan engines built by Metropolitan-Vickers were what is now called "aft-fan," and Armstrong Siddeley Motors did not continue their development, the new engine will have a front fan in the manner of a Pratt and Whitney JT–3D. It would be expected that a ducted fan, or a by-pass, engine would have a superior thrust/weight ratio to a pure jet engine of the same size, but the claims are made that the BE 53 will excel all existing engines in this respect despite having a thrust of the same order as that of an "Olympus," and that the fuel consumption does not suffer as a result of the high temperatures involved. It appears that the engine will be complete with ducts to direct gases downwards or rearwards, or forwards for reducing the landing run. It is not known whether this new development affects the choice of the "Olympus" for the TSR–2, which would appear to be able to use a by-pass engine to advantage.

NEW SWEDISH SHIPYARD AT ARENDAL.—A decision has been taken by Götaverken to build a new shipyard farther down the River Göta from Gothenburg. This will remove the limitation of the present yards to vessels of 40,000 tons, imposed by the width of the river. An area of about 1 square kilometre has been acquired at Arendal, four times that of the old yard. Facilities to be completed by the end of 1962, at an estimated cost of £10,000,000, will enable vessels of up to 100,000 tons deadweight to be constructed. The main installations will be two building docks, with covered erecting bays from one end of which the ships will emerge on a plate conveyor as each section is completed. By these and other novel methods for which patent protection is stated to have been sought, each vessel will be completed, including the installation of machinery and fitting out. Instead of a normal launch, the dock will simply be flooded and the ship towed out. Each dock can hold a 100,000-ton tanker or two tankers of 20,000 tons, and the total capacity of the yard will be of the order of 150,000 to 300,000 tons deadweight a year.

Launches and Trial Trips

ESSO NORWICH, oil tanker ; built by Ateliers et Chantiers de France for the Esso Petroleum Company, Ltd. ; length between perpendiculars 660ft, breadth moulded 90ft, draught loaded summer freeboard 35ft 4½in, deadweight 36,000 tons, load displacement 46,500 tons, service speed 17 knots ; one set of double reduction geared C.E.M.-Parsons turbines, 17,000 s.h.p. Trial, April.

SAINT REMI, oil tanker ; built by the Forges et Chantiers de la Gironde for the Compagnie Francaise d'Armement Maritime ; length between perpendiculars 543ft 6in, breadth moulded 73ft 10in, depth 40ft 4in, draught summer freeboard 30ft 11in, deadweight 20,580 tons, service speed 15·9 knots ; three 270kW diesel-driven alternators ; Schneider-Burmeister and Wain mark 774 V.T.B.F. 160 supercharged 8750 b.h.p. at 115 r.p.m. Trial, April.

ALTAIR, oil tanker ; built by the Chantiers de l'Atlantique Penhoët-Loire for the Compagnie Navale des Pétroles ; length between perpendiculars 704ft 5in, breadth moulded 102ft 1in, depth 50ft 6in, draught loaded 37ft 9in, displacement 61,960 tons, deadweight 47,835 tons, service speed 16·4 knots ; Penhoët-B. and W. mark 1274 V.T.B.F. 160, single-acting, two-stroke, engine, twelve cylinders, four turbo-blowers, 15,000 h.p. at 115 r.p.m. Trial, April.

ELEUTHERA, cargo ship; built by Hall, Russell and Co., Ltd., for the Pacific Steam Navigation Company; length between perpendiculars 360ft, breadth moulded 54ft, depth moulded 33ft 3in, deadweight 7350 tons on 25ft 9in draught; four holds, one—25 ton, four—10 ton and eight—5 ton derricks; three—175kW generators; Harland and Wolff four cylinder turbo-charged opposed piston engine, 4500 b.h.p. at 125 r.p.m. Trial, May 15.

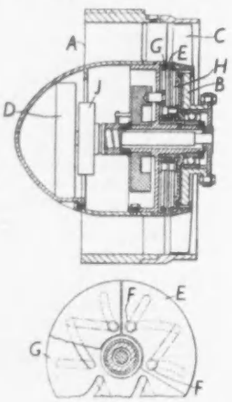
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

AIRCRAFT

812,911. February 16, 1956.—IMPROVEMENTS IN OR RELATING TO FLUID TURBINES, Plessey Company, Ltd., 56, Vicarage Lane, Ilford, Essex. (*Inventors: David Roy Trowbridge and Norman Moss.*)

This invention relates to ram turbines, which are driven by a stream of fluid in which the turbine is immersed. A typical example of the use of a ram turbine is in aircraft where it can be used for providing power for auxiliary equipment particularly in the event of failure of the main turbine. The air turbine may be normally stowed away but when needed can be swung into the air stream to provide the power, thus enabling a pilot to operate the aircraft controls. As the turbine must be designed to supply, even at low gliding speed, the maximum auxiliary power that may be required for operating the controls, its speed is liable to become excessive when the aircraft speed is high and/or little or no auxiliary power is consumed. According to the invention baffle plates are provided which, when the turbine speed rises above a predetermined value, progressively reduce the cross-section of an aperture through which the fluid driving the turbine must pass. The drawing shows an elevation of such a



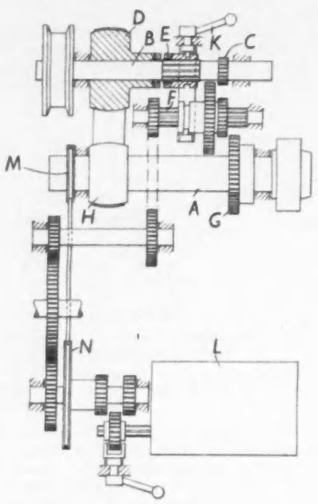
No. 812,911

ram air turbine in which an annular air duct *A* is formed between a substantially cylindrical wall and an inner housing. A rotor *B* with blades *C* extending across the duct is coupled to the power-input shaft of a hydraulic pump *D* by a flange. In order to prevent the turbine speed from rising unduly when the aircraft moves at high speed and/or the hydraulic load is light, a set of obturator or baffle segments *E* are arranged slightly in front of the inlet edges of the rotor blades and are normally accommodated within the housing so as not to interfere with the flow of air through the turbine. Each segment carries two pins *F*, and the two ends of each pin engage grooves or slots in two side plates *G* and *H* in the housing. The side plate *H* is fixed in the housing, while the other plate *G* is rotatable. As can be seen in the lower view, on rotation of the plate *G* the plate *H* will move towards, or away from, the rotor axis, causing the segments *E* to move in respect to passage *A* to reduce or increase the quantity of air passing through. In order to adjust plate *G* automatically, a centrifugal governor *J* displaces a nut which through a coupling means to the disc *G*, causes the segments *E* to move to an extent depending on the amount of excess speed of the turbine.—*May* 6, 1959.

MACHINE TOOLS

813,061. June 17, 1957.—LATHE OR MACHINE TOOL DRIVE, Colchester Lathe Company, Ltd., Hythe, Colchester, Essex. (*Inventor: Arthur Jose Firth.*)

The drawing illustrates a mechanism embodying the invention applicable to a conventional centre lathe. Parallel with the main spindle *A* of the lathe is a power-input shaft *B* driven from any convenient source. On the shaft *B* is secured a pinion *C* and a freely mounted belt pulley *D* which is engageable with the shaft by a slidable splined clutch *E* operable by a hand lever. Between the input shaft *B* and main spindle *A* is a splined countershaft *F* carrying a pair of pinions of different diameters, the larger pinion being engageable with the pinion *C* and the smaller with a pinion *G* forming a train through which motion can be transmitted from the input shaft to the main spindle at a conveniently reduced rate. A belt pulley *H* on the main spindle is con-



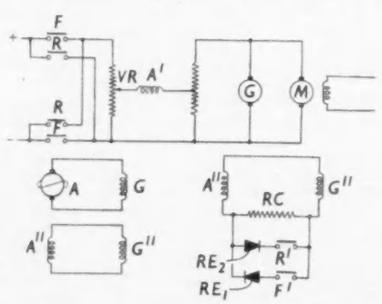
No. 813,061

nected to the pulley *D* on the input shaft, pulley *D* being preferably of smaller diameter, so that motion can be transmitted from the shaft to the spindle at an increased rate. By means of the above mechanism motion can be transmitted from the input shaft to the main spindle through either of two paths under the control of the lever *K* which acts on both the clutch and on the input shaft and the slidable pinions on the countershaft, the arrangement being such that when motion is transmitted through the pinions the belt pulley on the input shaft is free, and when the belt pulley is brought into action, the pinions on the countershaft are inoperative. For transmitting motion to the feed gear box *L*, two alternative paths are also provided, one consisting of a train of pinions and the other a belt pulley *M* on the main spindle, and a larger pulley *N* connected to a second gearbox driving pinion. In screw-cutting operations, motion is transmitted to the main spindle, and the feed box spindle through the pinions; for other purposes the motion may alternatively be transmitted through the belt pulleys.—*May* 6, 1959.

ELECTRICAL ENGINEERING

812,464. September 19, 1957.—CONTROL SYSTEMS FOR ELECTRIC MOTORS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor: Geoffrey Edmund Woodliff.*)

This invention relates to the control of electric motors particularly suitable for winder plants, where the motor is supplied from a variable voltage generator, such as a Ward-Leonard set, for speed regulation. It aims at providing an improved arrangement for producing different rates of response during deceleration and acceleration periods. The specification illustrates a conventional system for the



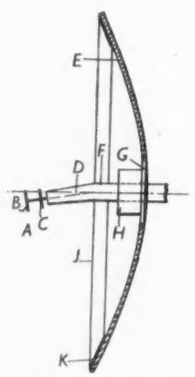
No. 812,464

control of a winder motor *M* (upper drawing) supplied by a generator *G* of which field winding G^1 is excited by the amplidyne machine *A*, the field winding A^1 of which is energised according to the difference between a reference voltage derived from potentiometer *VR* and a portion of the generator voltage. When the setting of *VR* is changed, there is a change in voltage across G^1, inducing a change of opposite polarity across G^{11} and hence in amplidyne winding A^{11}, the latter opposing A^1 and so introducing a delay in control response. In order that the rate of response during deceleration may be different, and in particular less, from that during acceleration, the invention proposes an alternative arrangement of the A^{11}–G^{11} circuit. This is shown in the lower right-hand drawing. Resistance RC between windings G^{11} and A^{11} is by-passed by one shunt circuit consisting of a unidirectional current carrying device or rectifier RE^1 in series with a switch F^1, and by another shunt circuit consisting of a rectifier RE^2, oppositely poled to rectifier RE^1, in series with a switch R^1, the operation of the switches F^1, R^1 being suitably interconnected with that of the forward and reverse switches *F*, *R*, of the main control.—*April* 22, 1959.

TELECOMMUNICATIONS

812,196. October 30, 1957.—AERIAL SYSTEMS, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. (*Inventor: Alfred George Hayes.*)

This invention relates to aerial systems and is more particularly concerned with directional aerial systems of the kind comprising a primary aerial, such as a dipole or a more complex array, in combination with a reflecting surface. In a known construction of directional aerial system comprising a dipole and a dish-shaped metal reflector, the main lobe of the radiation pattern subtends a relatively narrow angle although there are also a number of side lobes, these being arranged to be of smaller amplitude than the main lobe. For some purposes, for example in a radar system, these side lobes are undesirable and it is one object of the present invention to provide an aerial system in which the amplitudes of these side lobes are reduced. It is believed that they are caused, at least in part, by the electrical discontinuity at the edges of the reflector, and this discontinuity is reduced by the present invention. Referring to the drawing, a primary aerial *A* is formed by a pair of



No. 812,196

dipoles *B* and *C* and is mounted so that it is slightly off the axis *D* of the paraboloid *E*. A feeder waveguide *F* is associated with the primary aerial and passes through a central circular hole in the reflector. Member *G* is secured to the feeder waveguide so as partially to fill the hole, this member having a surface which forms a continuation of the paraboloidal surface of the reflector. In order, during transmission, to prevent energy being reflected back from the reflector to the primary aerial so as further to excite that aerial and thereby cause multiple transmissions, a small additional reflector *H* is provided. This is annular in shape and embraces the feeder waveguide to which it is secured. The primary aerial, waveguide, member *G* and additional reflector *H* form an integral structure so mounted that during operation it rotates about the axis *D*. The effect of this is that the primary aerial sweeps out a path which embraces the axis in the region of the focus of the reflector. The electric discontinuity at the edge *J* of the reflector is reduced by providing a band *K* of lossy material. This material is fixed to the surface *E* of the reflector and the band is of uniform width the whole way round the reflector. The thickness of this band may be tapered so that the resistance per unit area increases radially towards the edge *J* of the reflector. A similar effect may be obtained if the lossy material is of uniform thickness (so that its resistance per unit area is uniform) while the inside edge of the band follows a zig-zag line. The lossy material may be any known radar absorbing material such as graphite-loaded rubber.—*April* 22, 1959.

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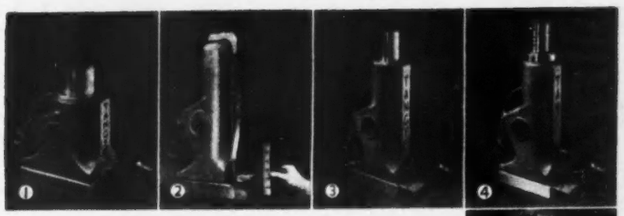

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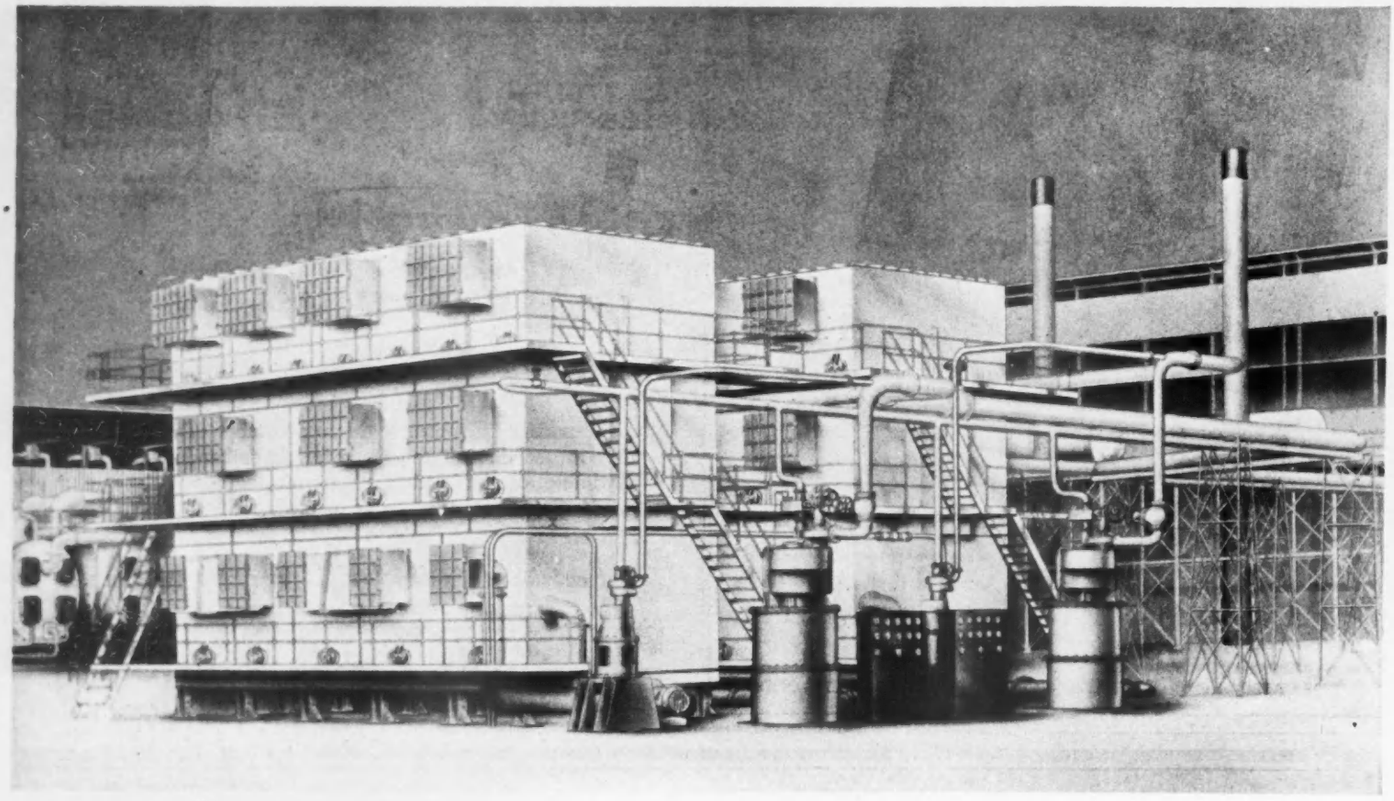

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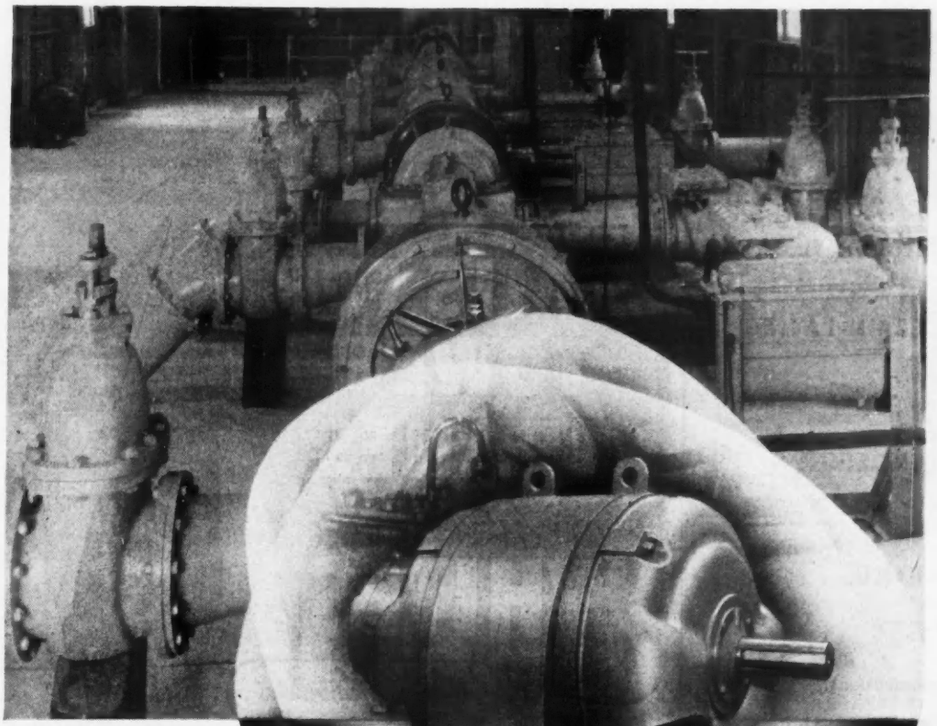

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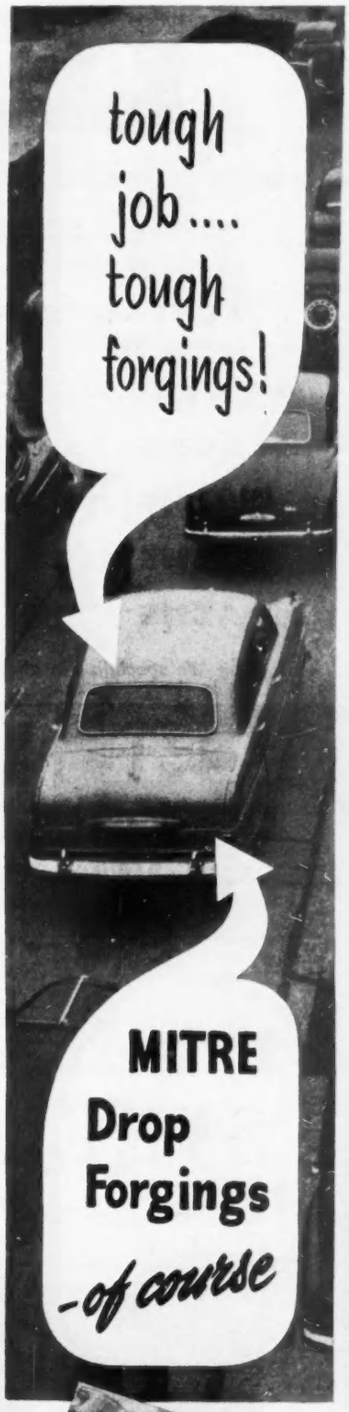

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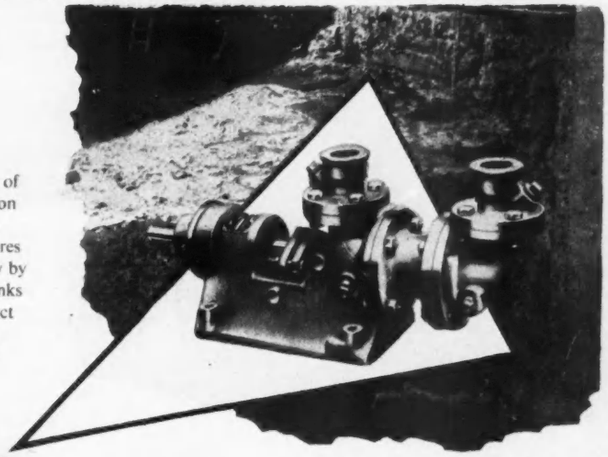

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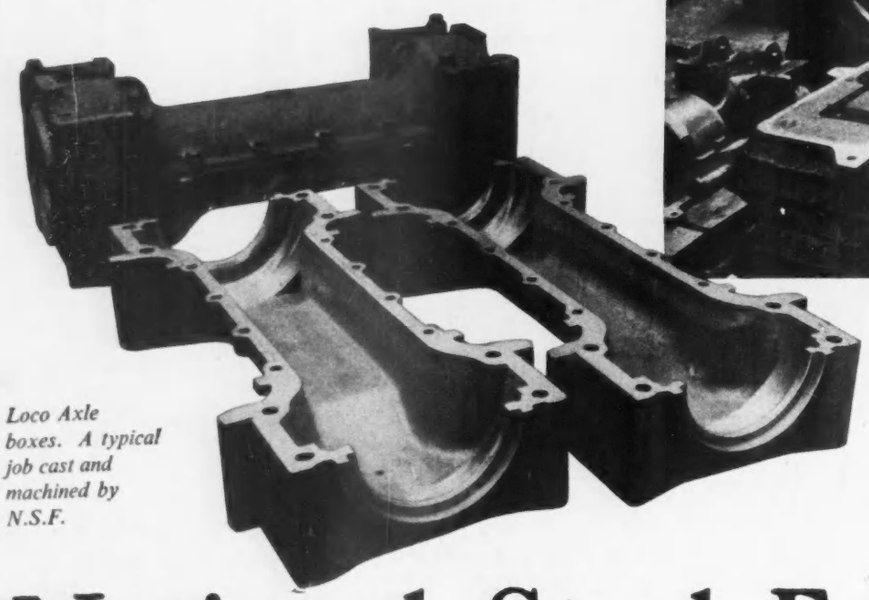

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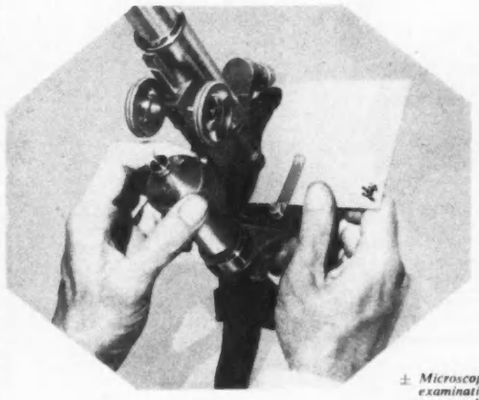

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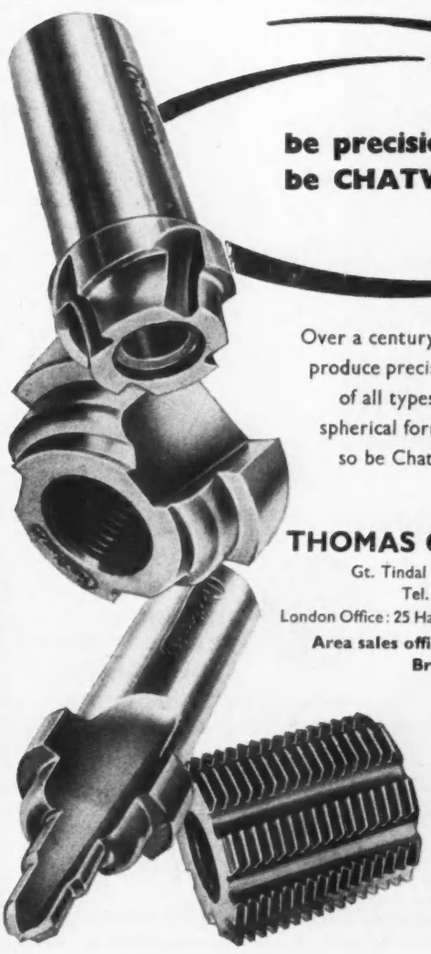

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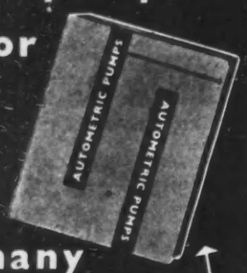

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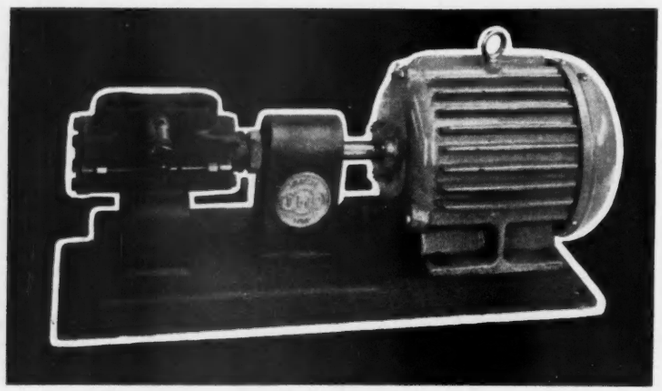

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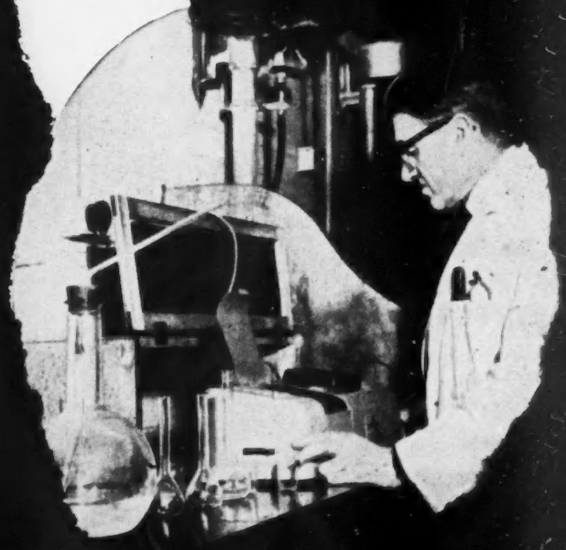

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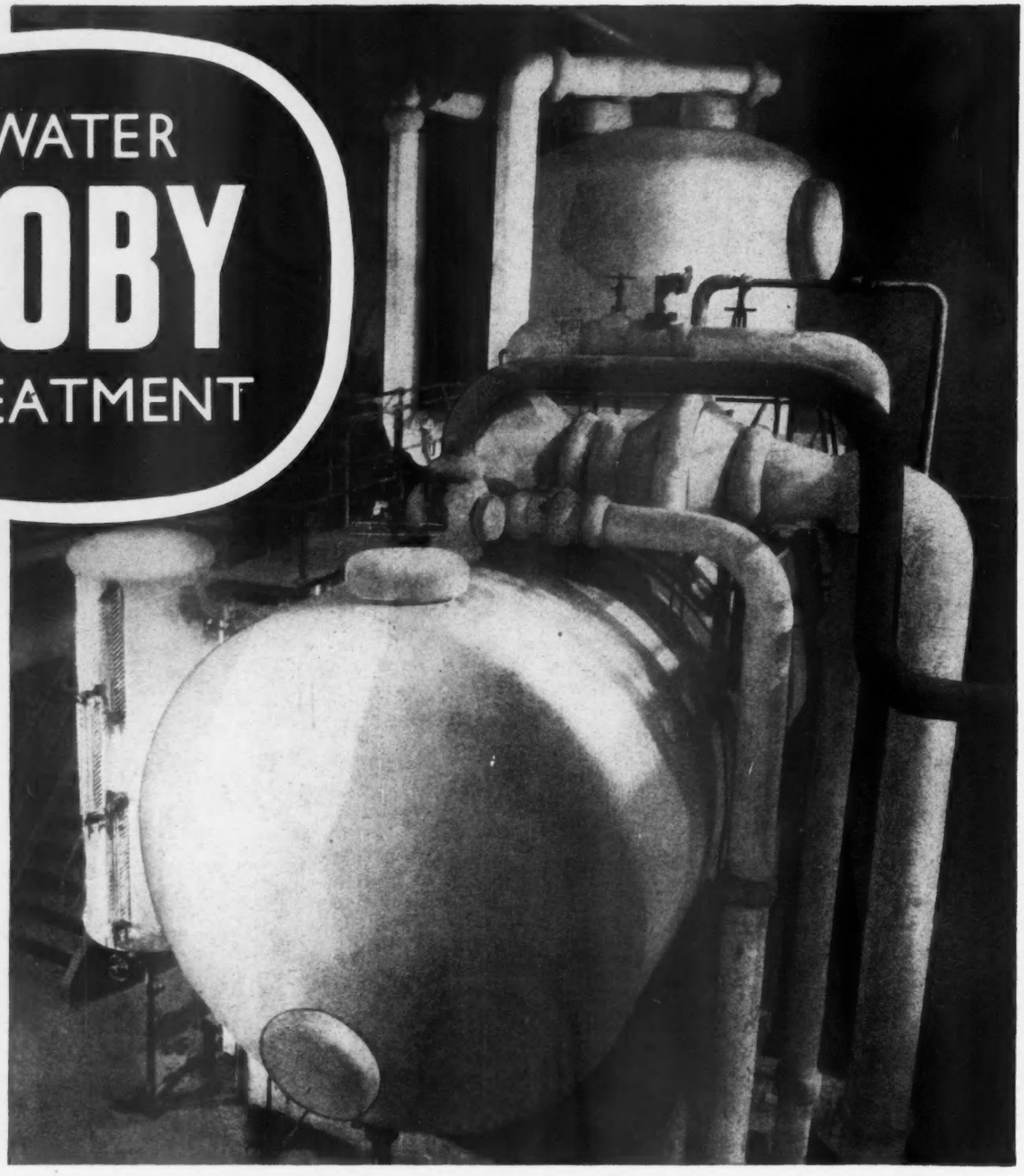

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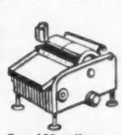

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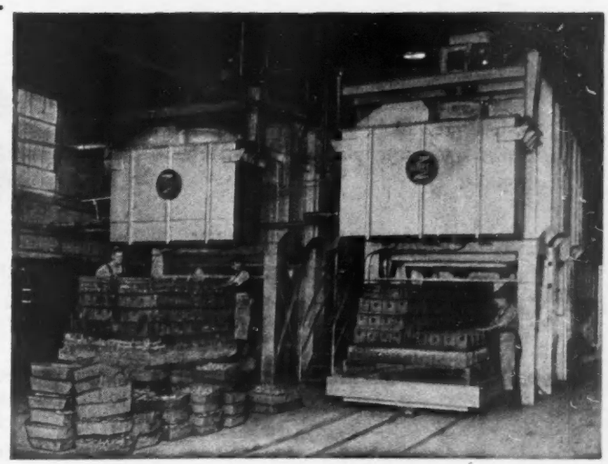

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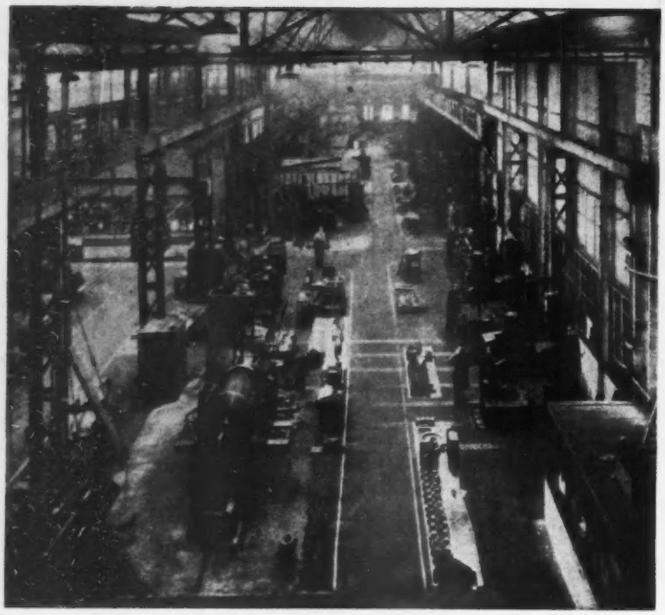

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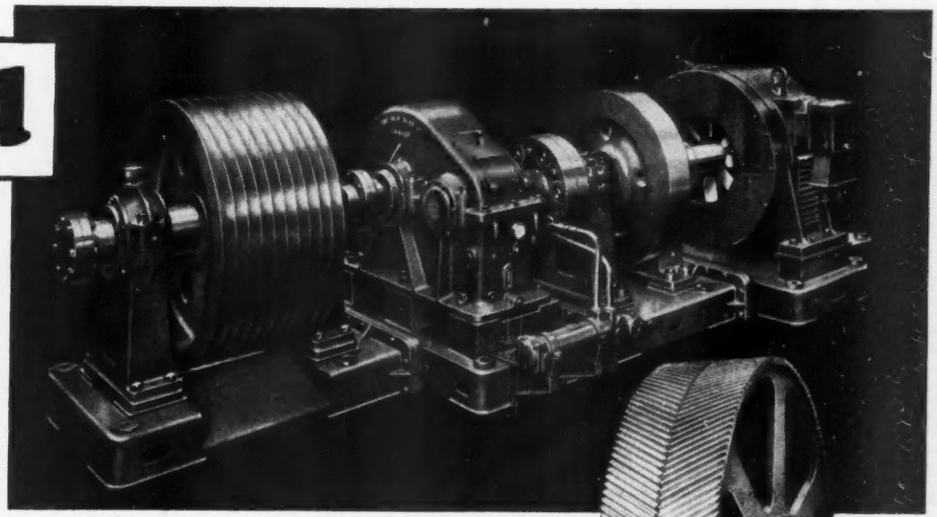

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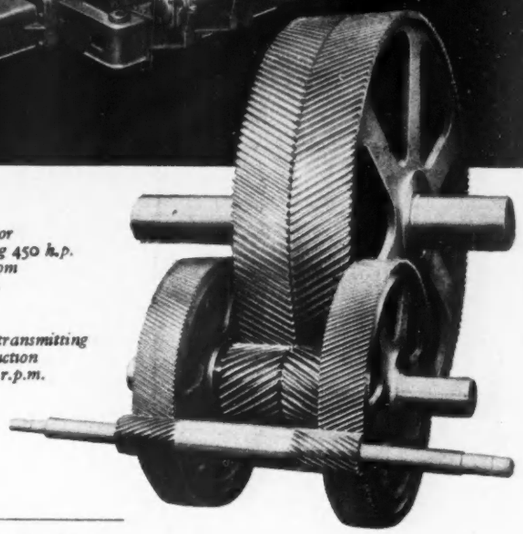

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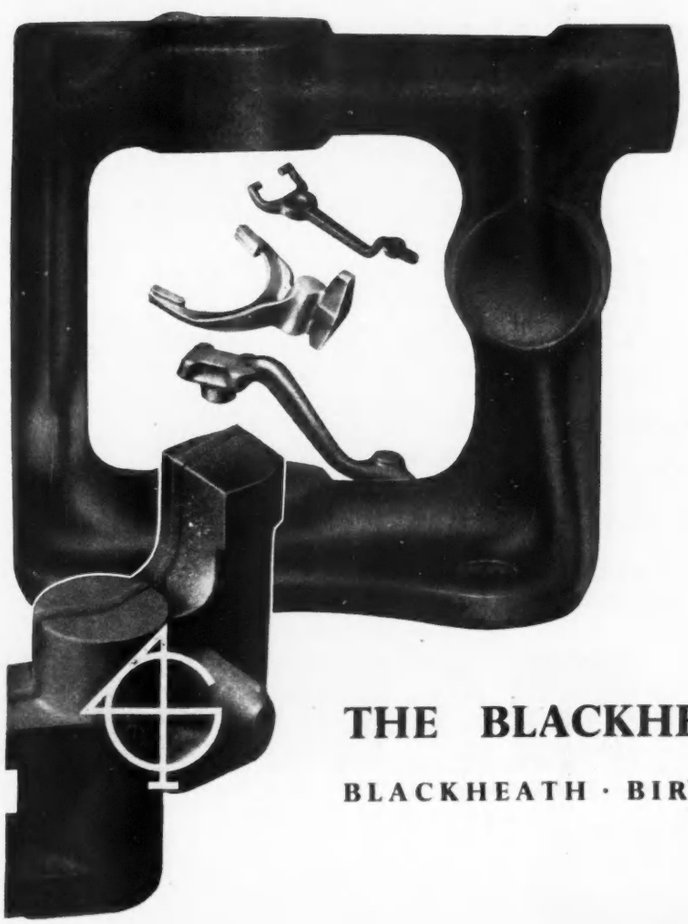

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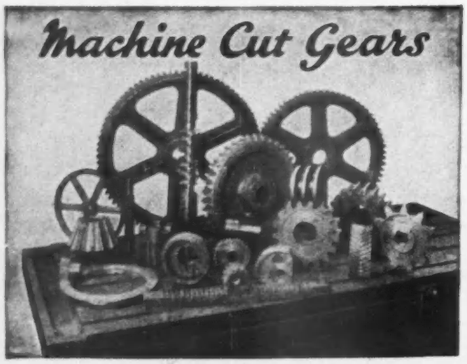

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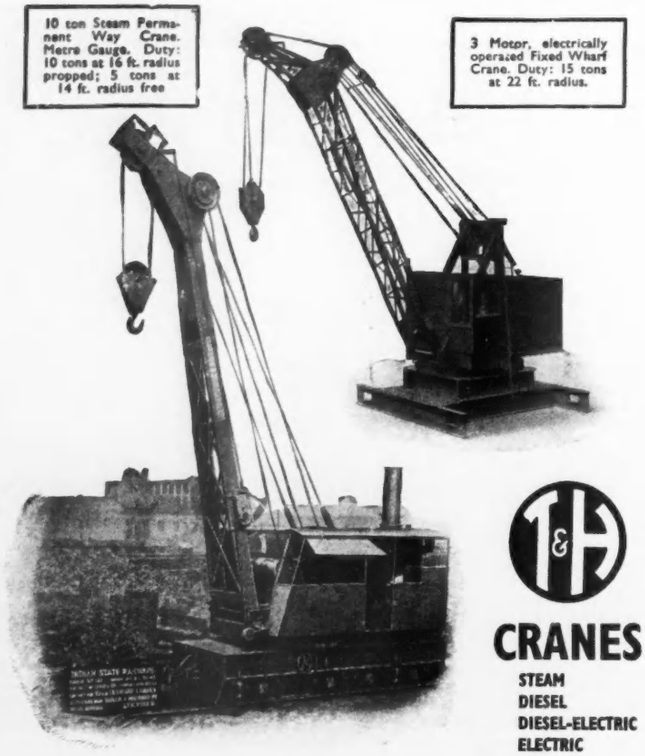

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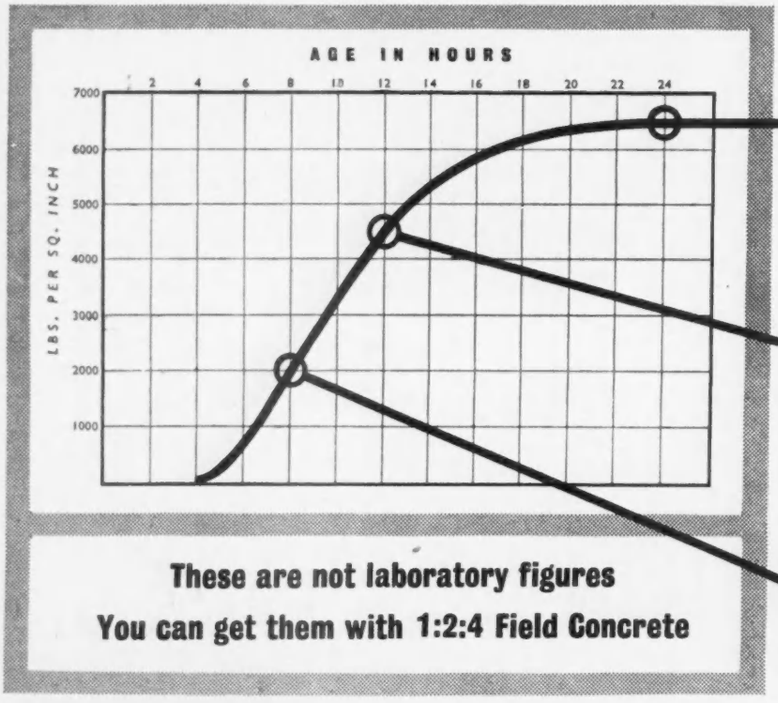

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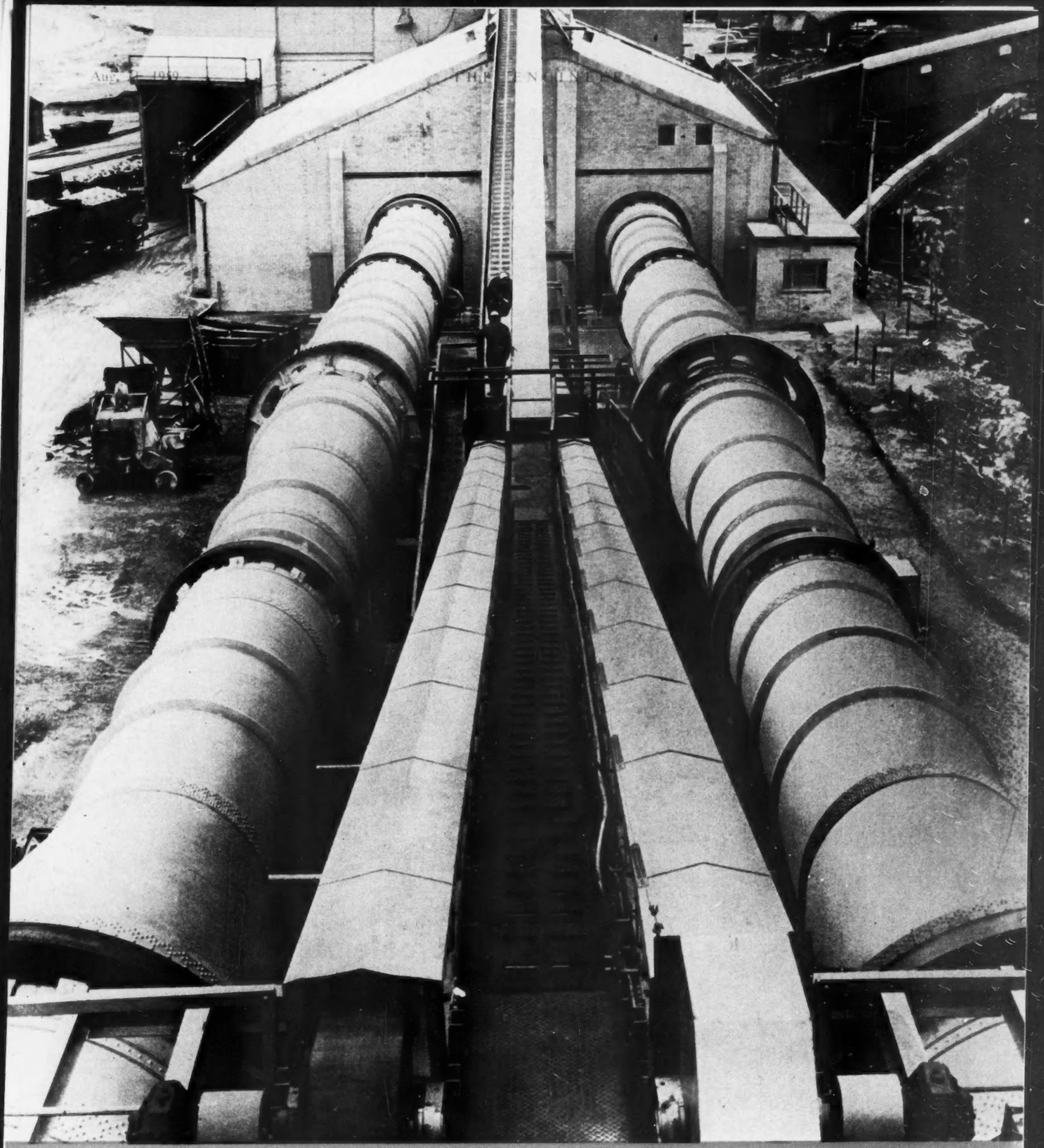

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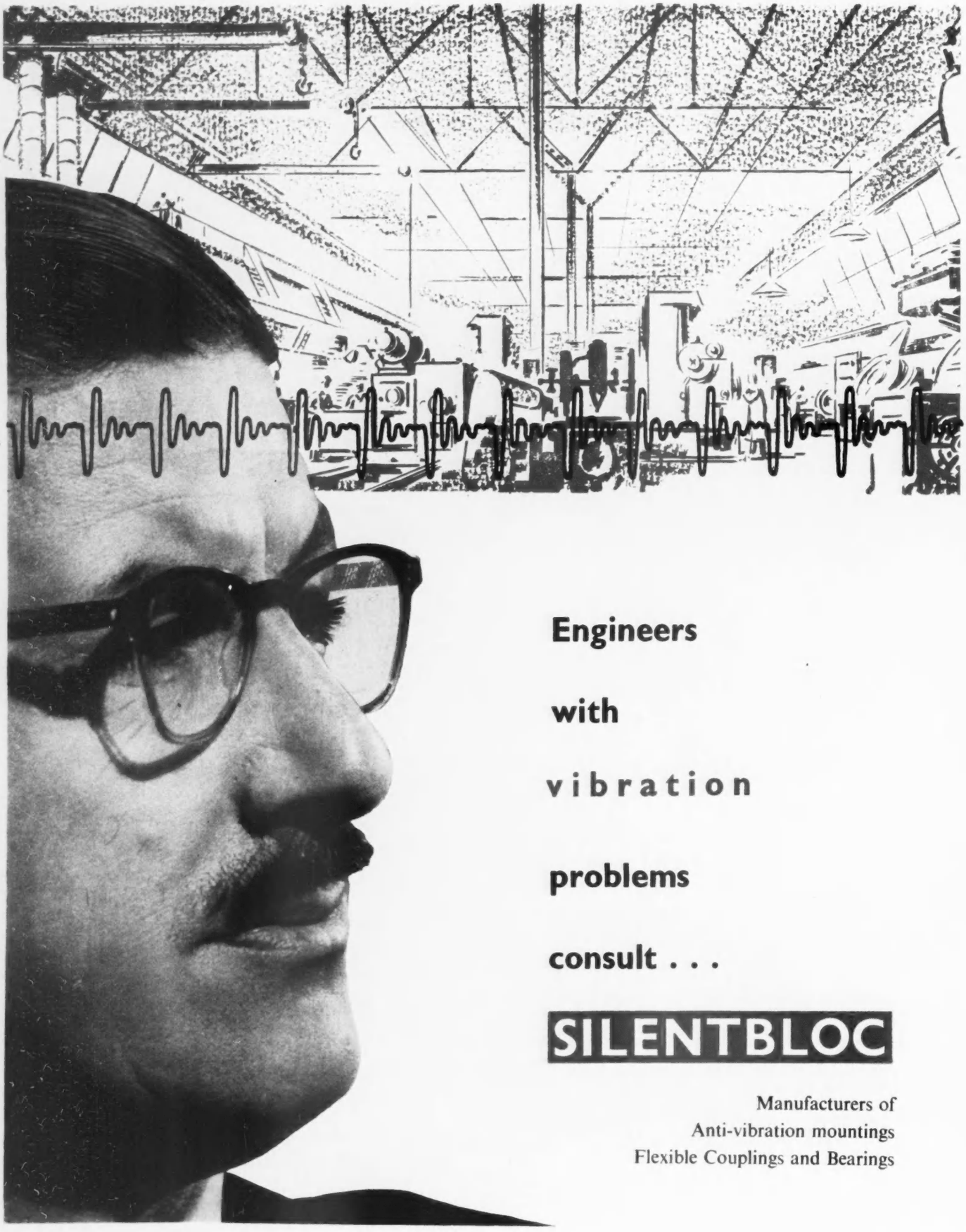

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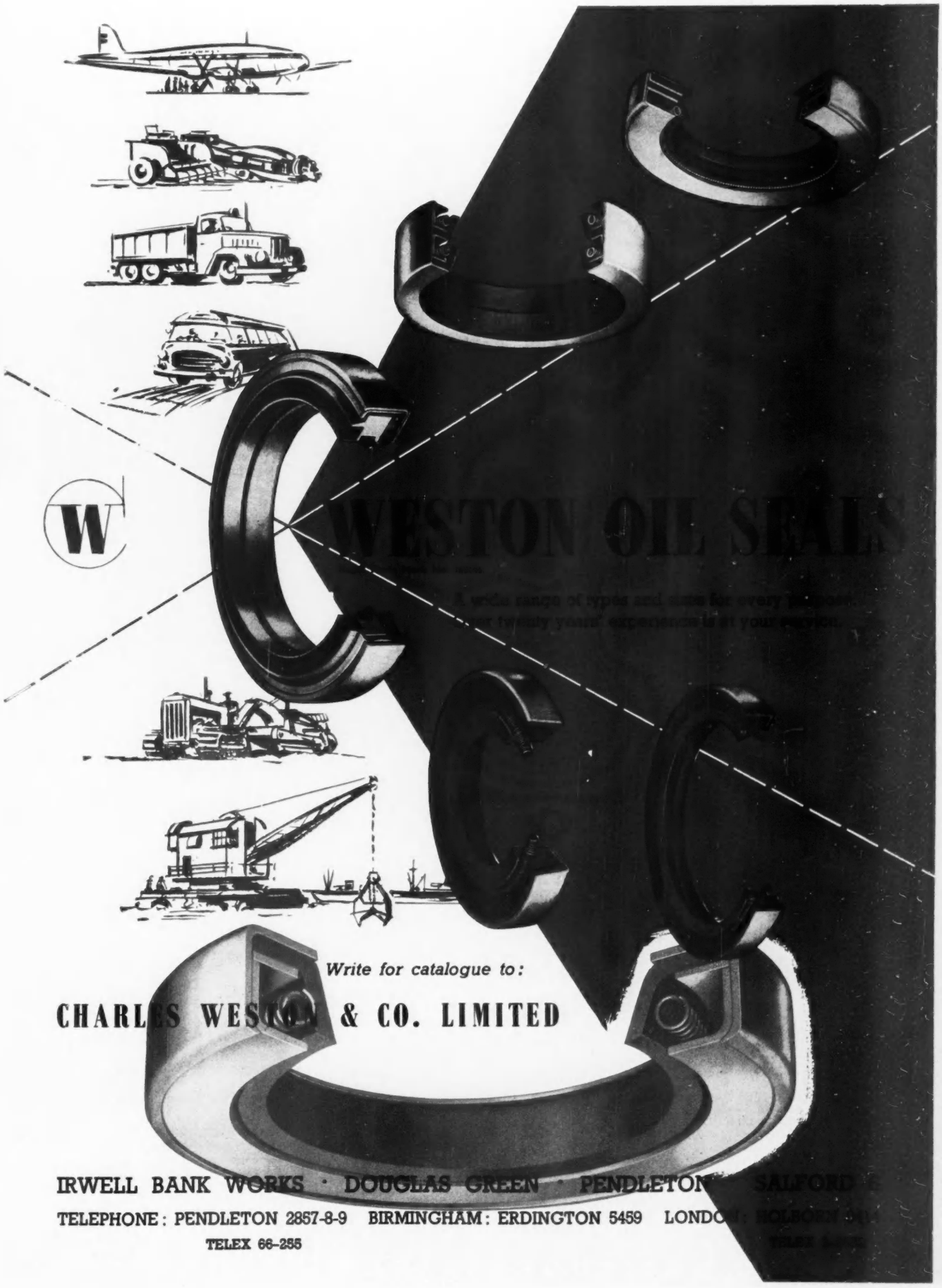
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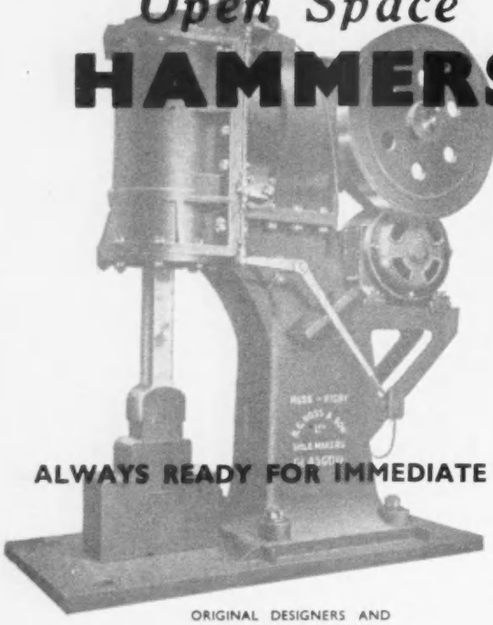

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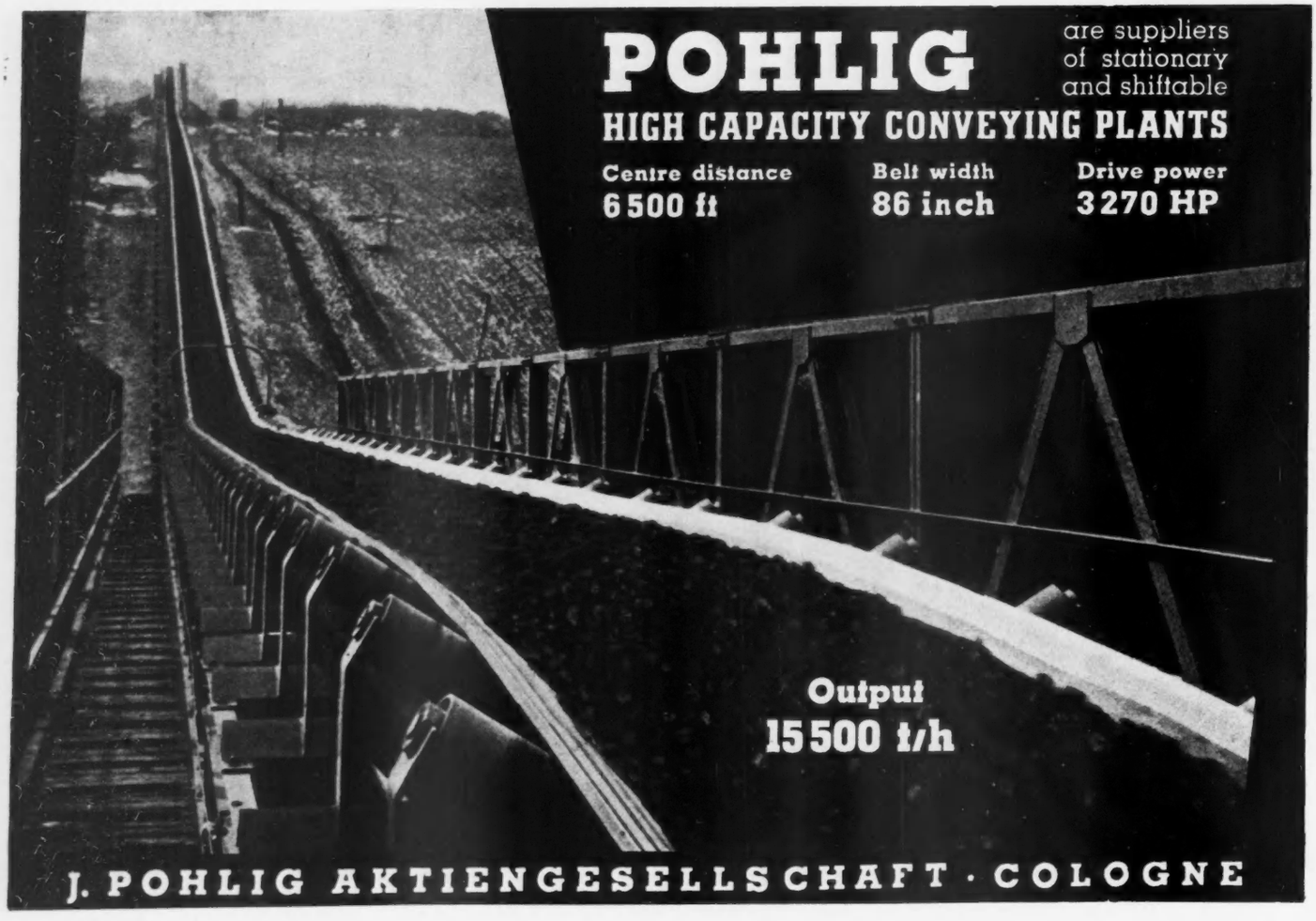

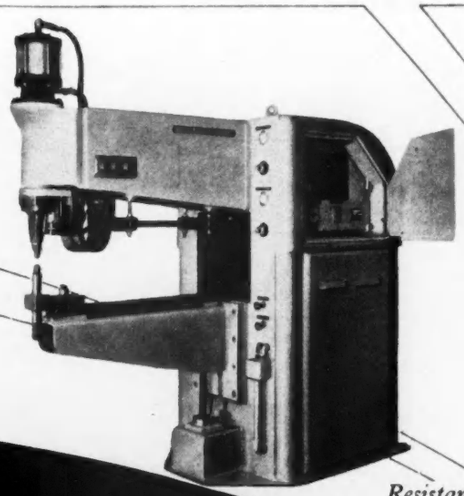

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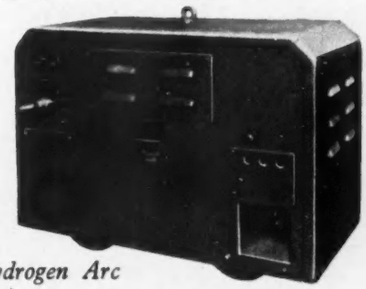

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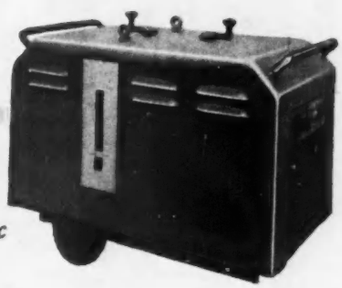

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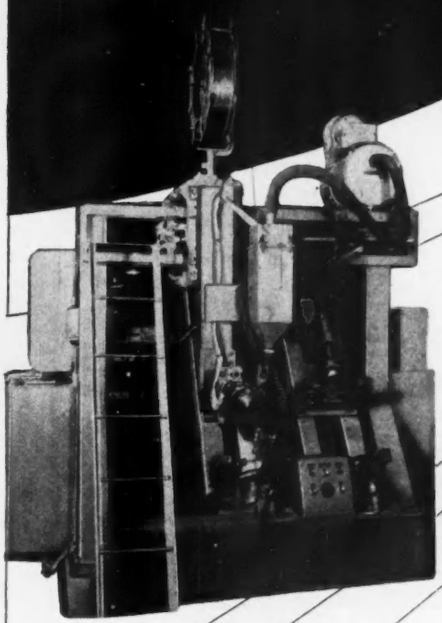

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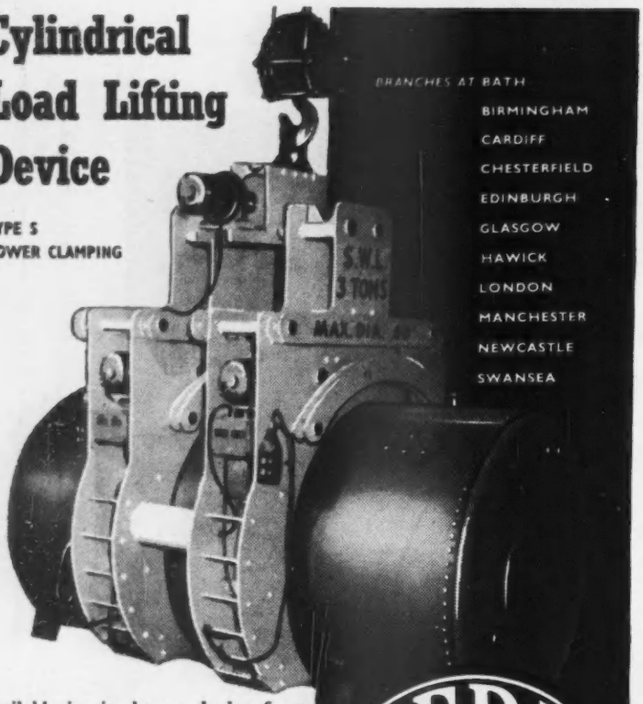

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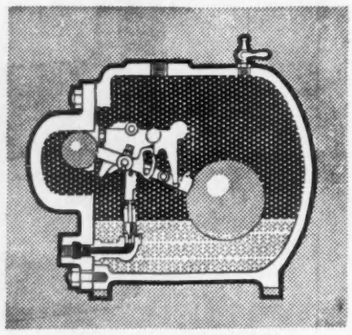

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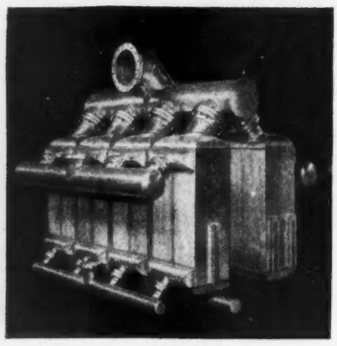

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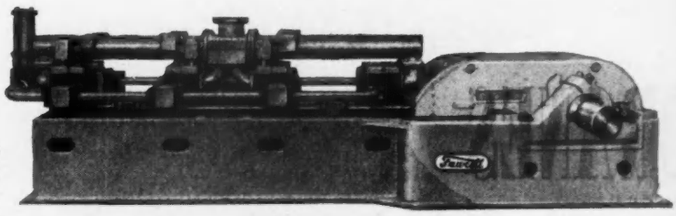

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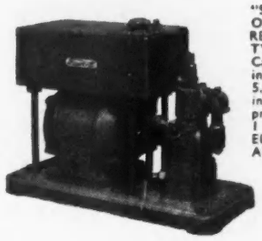

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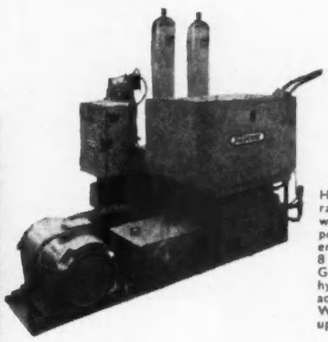

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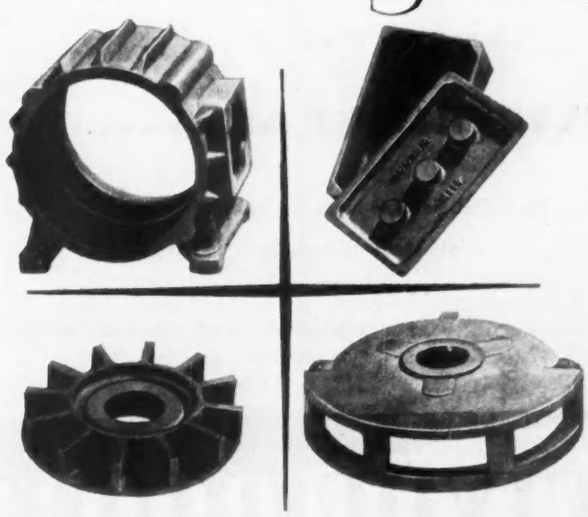

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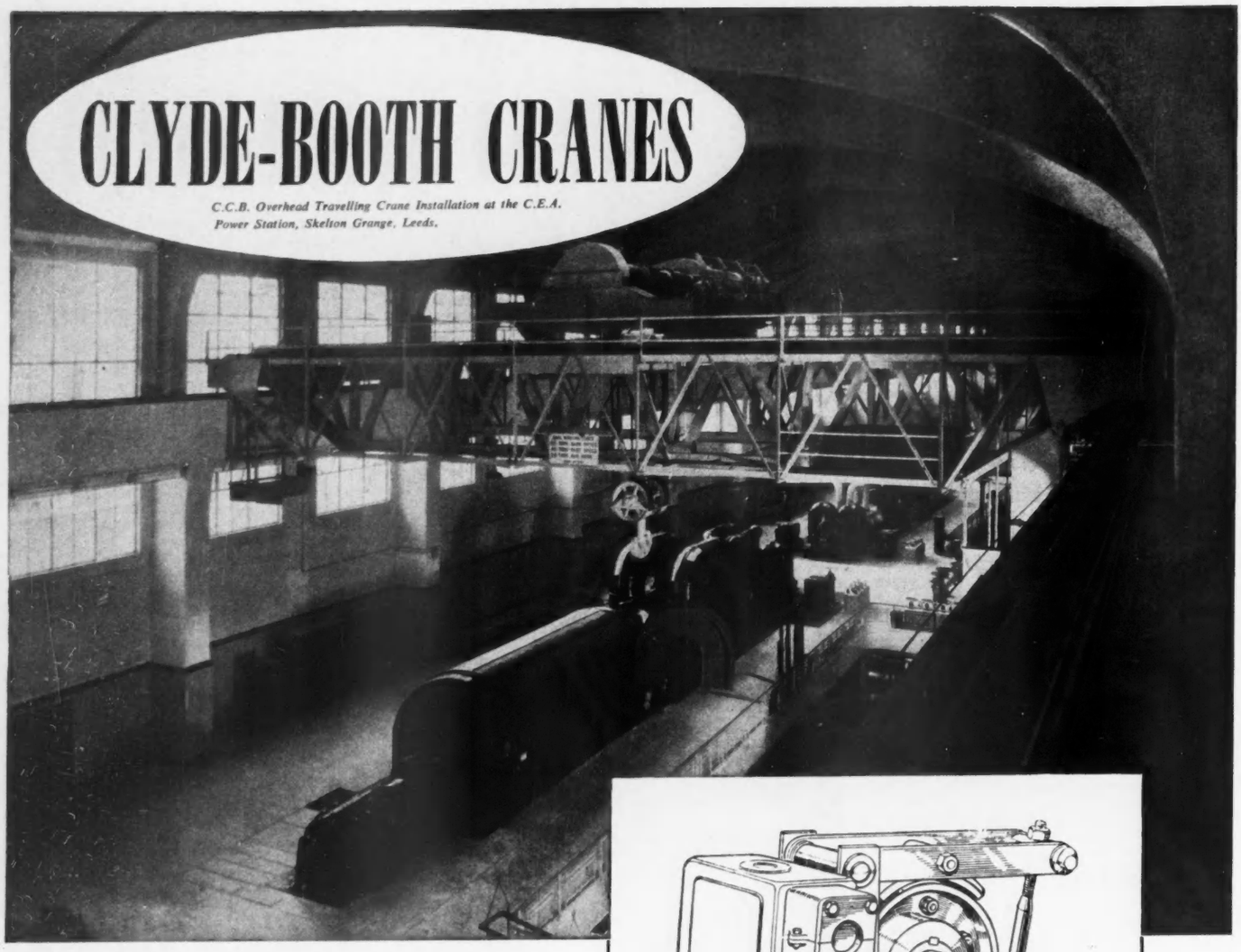
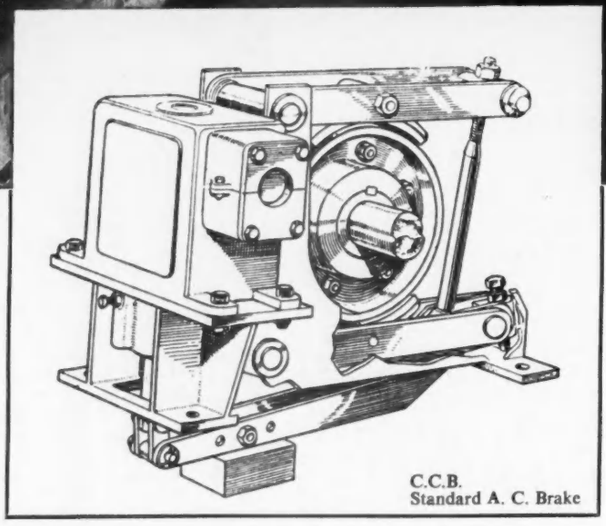
C.C.B. Overhead Travelling Crane Installation at the C.E.A. Power Station, Skelton Grange, Leeds.





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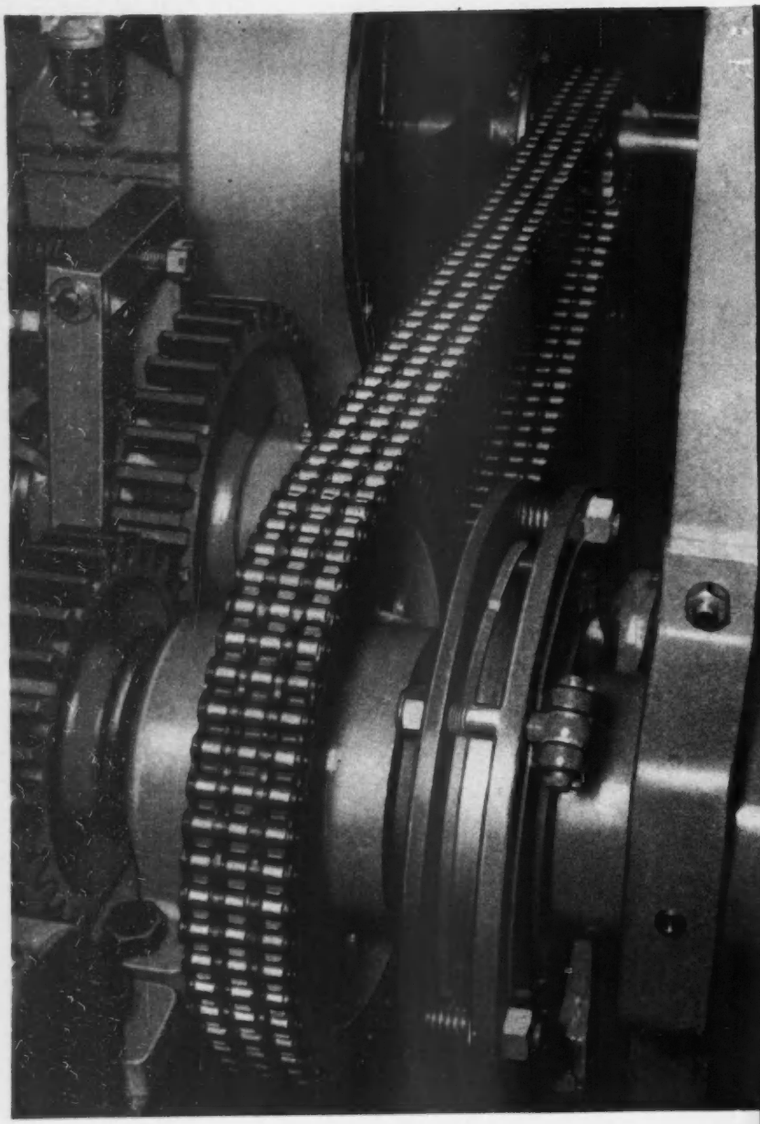

Illustrated is the main drive from power unit to power take off by a PERRY No. 34612 ¾" pitch × .460" wide triplex roller chain on the Jones K.L. 44 Mobile Crane. Photograph by courtesy of Messrs. K. & L. Steelfounders Limited.

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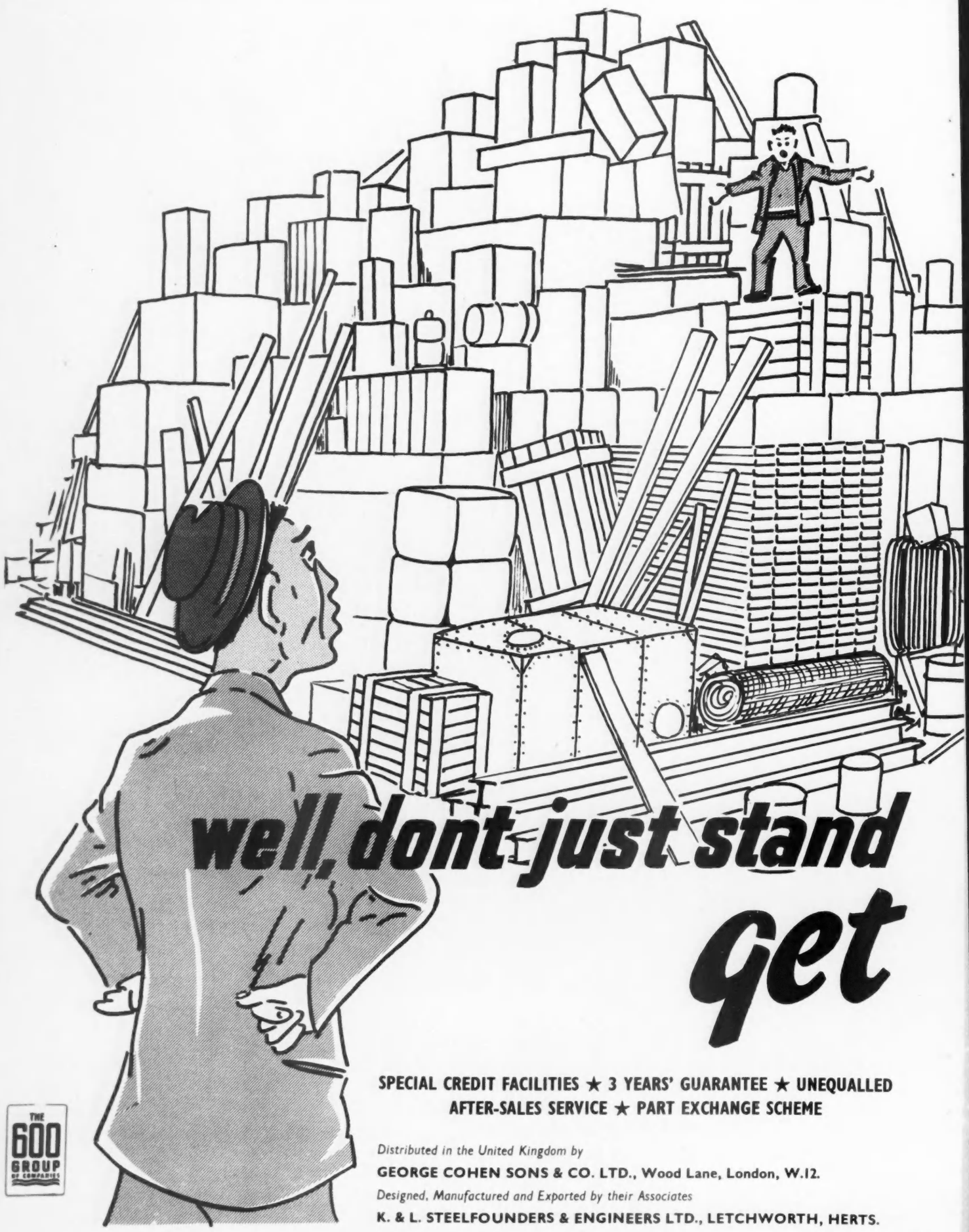

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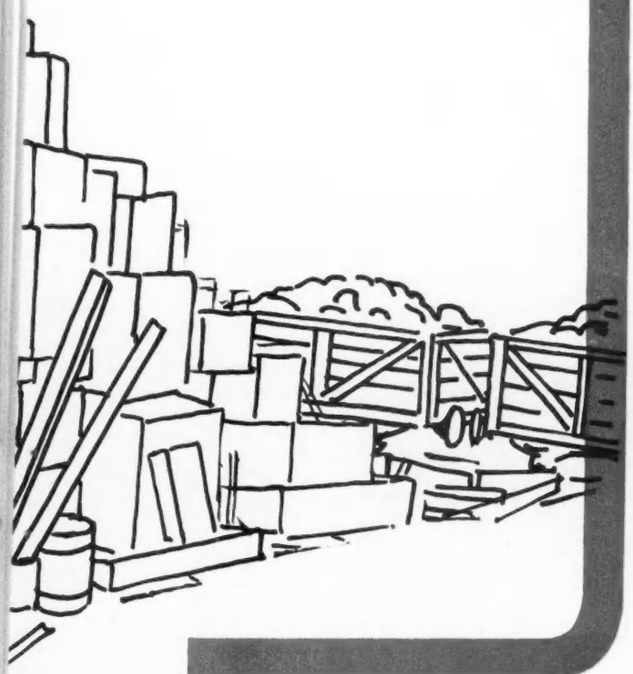

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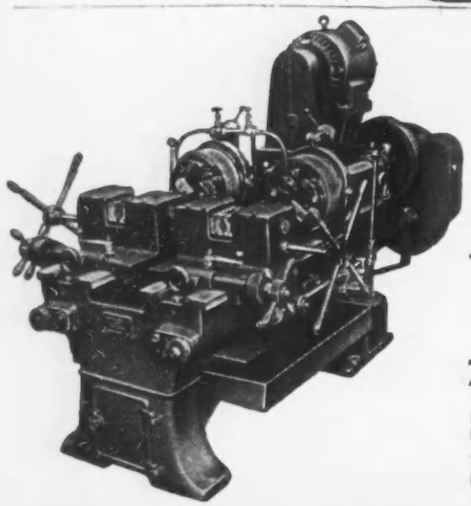

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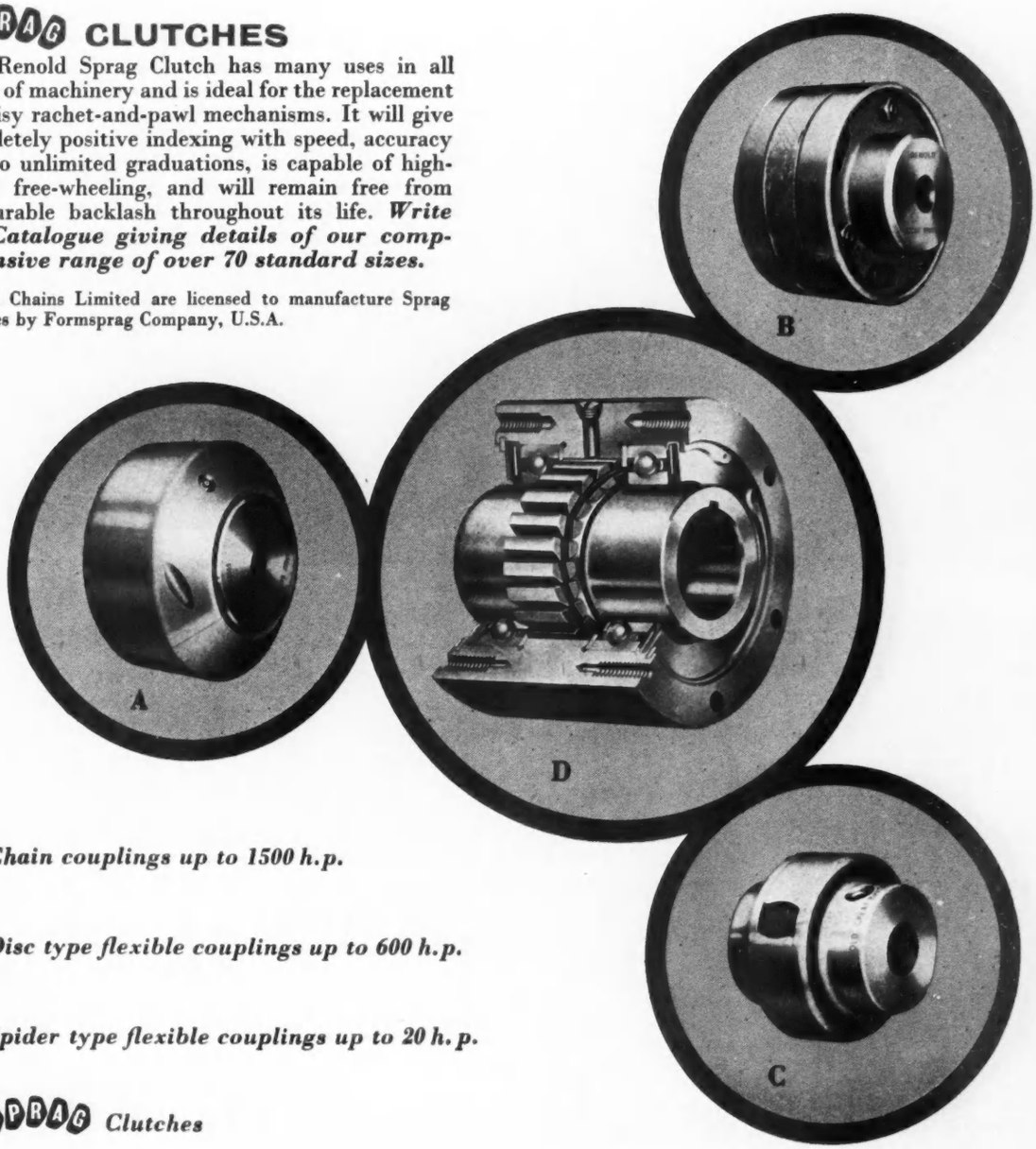

A *Chain couplings up to 1500 h.p.*

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D SPRAG *Clutches*

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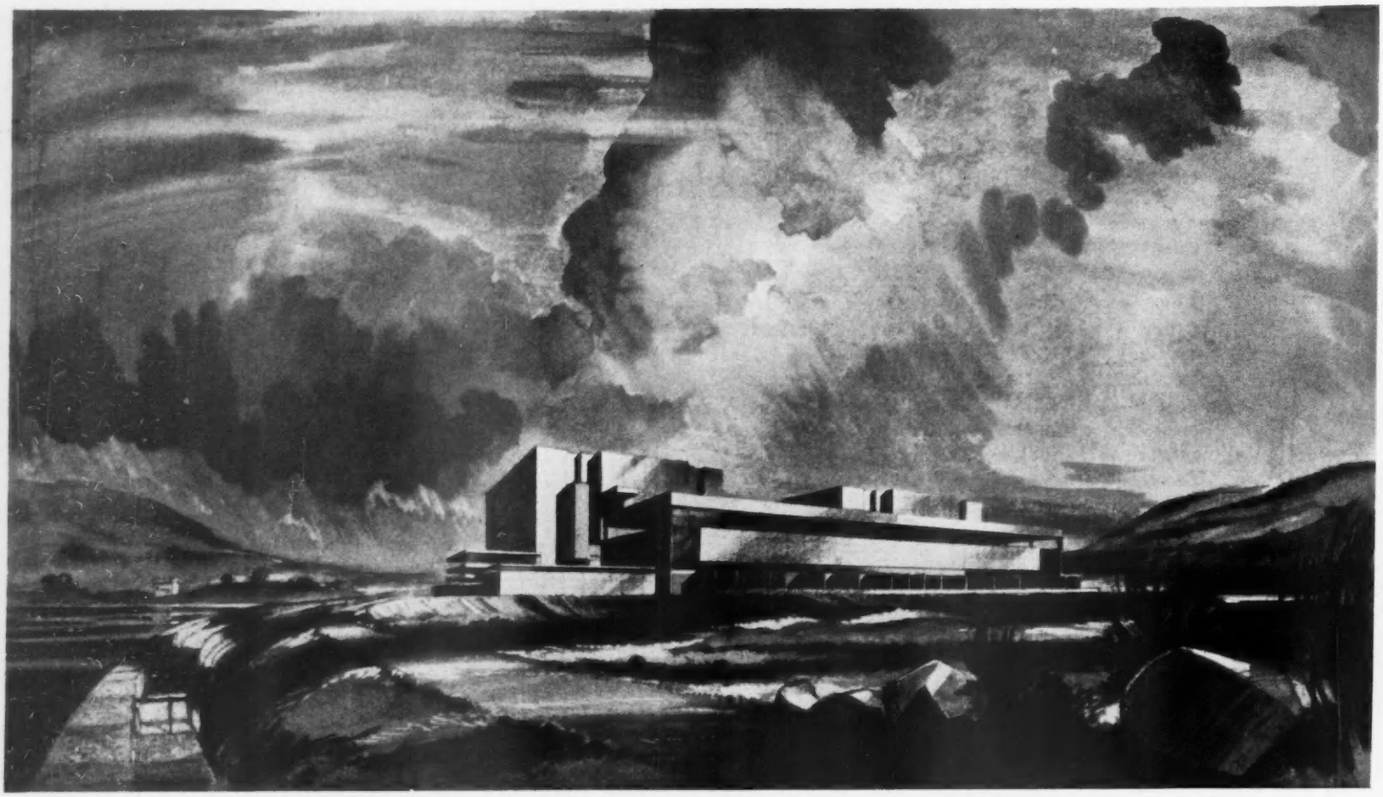
Trawsfynydd
NUCLEAR POWER STATION



This impression of Trawsfynydd Nuclear Power Station by Mr. Basil Spence A.R.A., *President* R.I.B.A., *Consultant architect to Nuclear Civil Constructors, shows how the design blends into the landscape of Snowdonia.*

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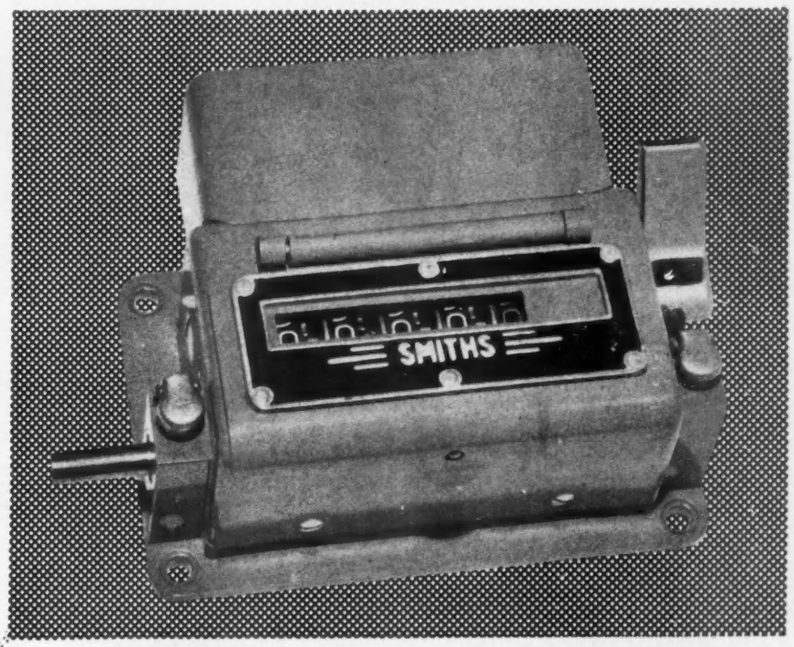
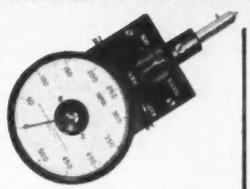


Specification

Body:	Die-cast alloy, reasonably dust- and dirt-proof.
Counter:	White on black figures.
Speed of Count:	4,000 counts/min. Maximum Shaft Speed: 5,000 r.p.m.
Drive:	R.H. or L.H., plain shaft or flex attachment.
Rotation:	Top going or top coming.
Micro Switch:	Supplied in wide choice of agreed manufacturer/client ratings.
Total Weight:	With flex attachment, 2 lb.; plain shaft, 1 lb. 15 oz.



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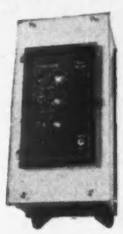

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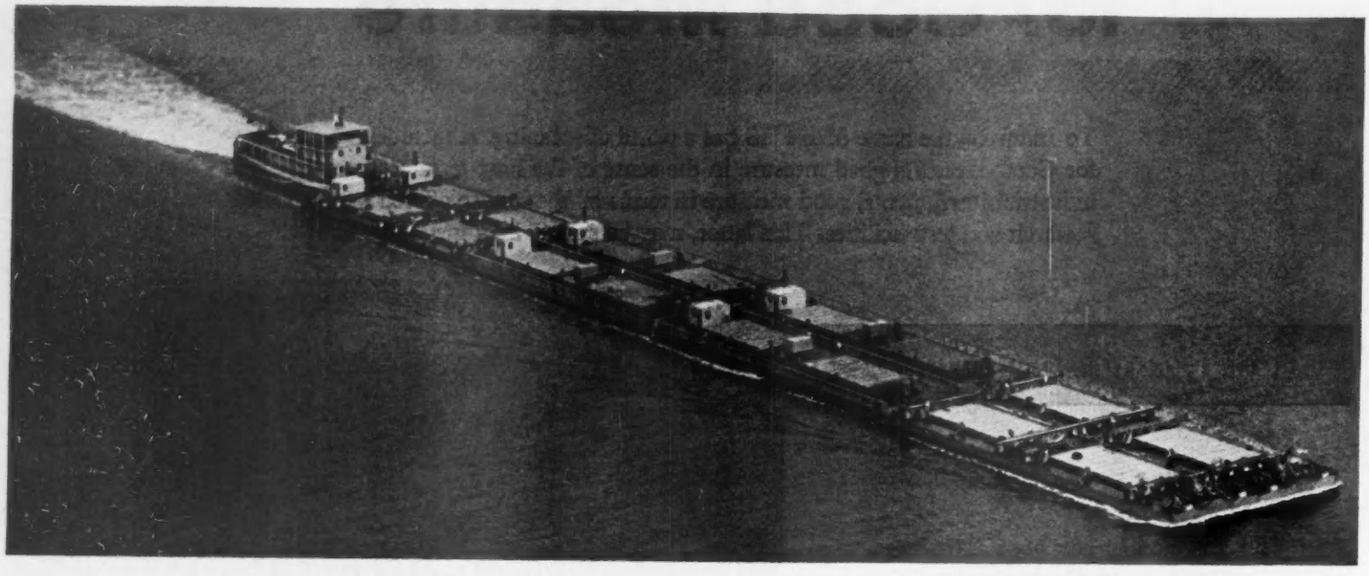

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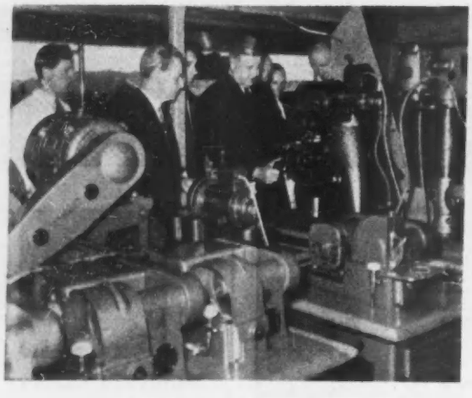

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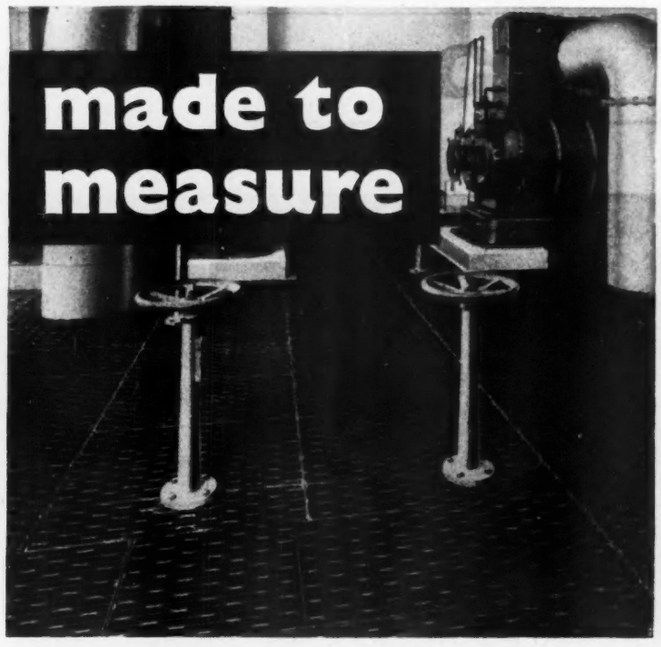

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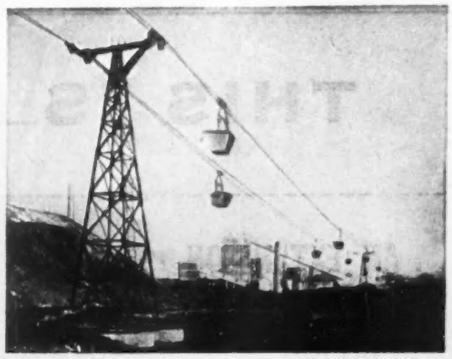

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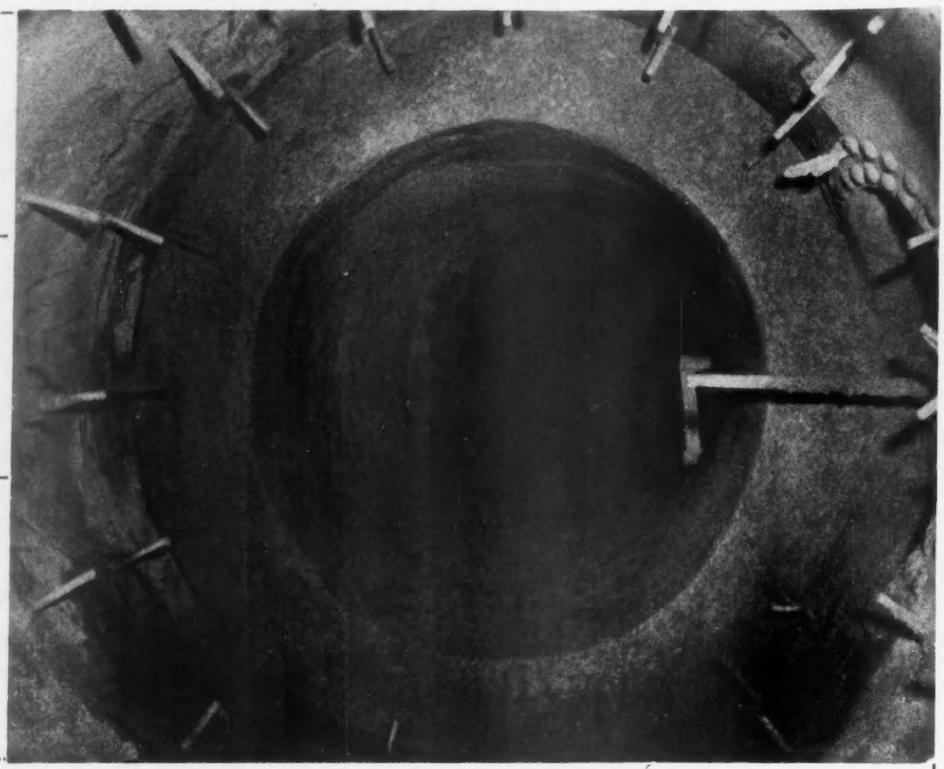
3 . . . THE INLET PIPE OF A HYDRO-ELECTRIC POWER STATION



Number two is the answer. It is in fact the bustle-main of the Queen Victoria blast furnace at Appleby-Frodingham in course of being lined with Tri-Mor 'Guncrete'. The main is 5 ft. in diameter and the 'Guncrete' lining 9" thick. This is a far quicker and cheaper form of lining for a hot-gas main than brickwork. After twelve months continuous service this lining is still in perfect condition. Brick-lined mains usually require considerable repair after this period.

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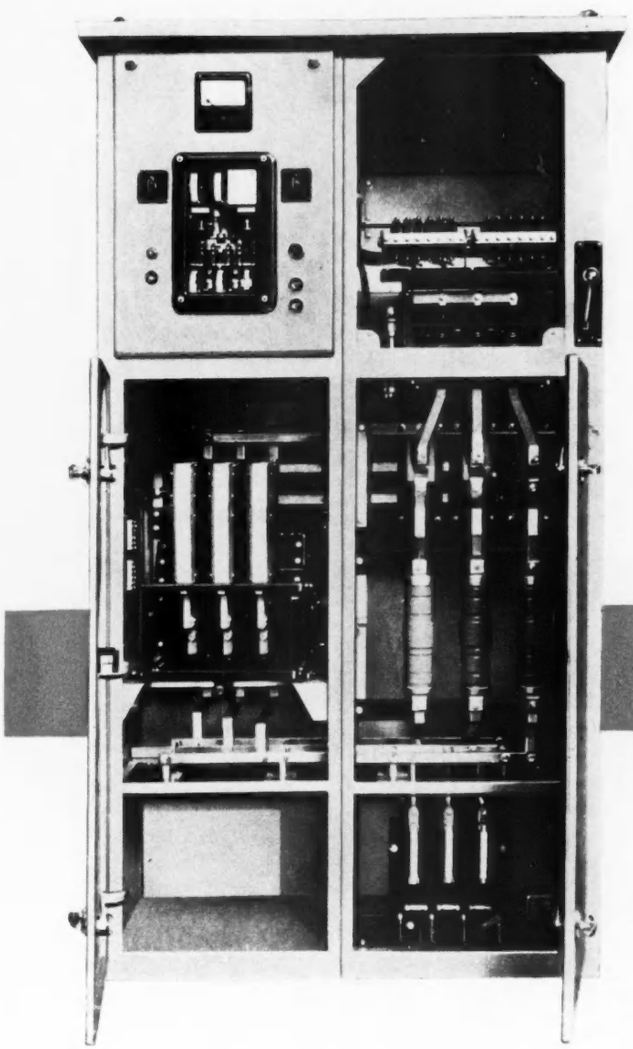
THE BELMOS 3·3 kV AIR-BREAK CONTACTOR STARTER



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- ★ Optional earth leakage protection.
- ★ Comprehensive control arrangements, local and remote, with sequence interlocking and automatic sequence starting.
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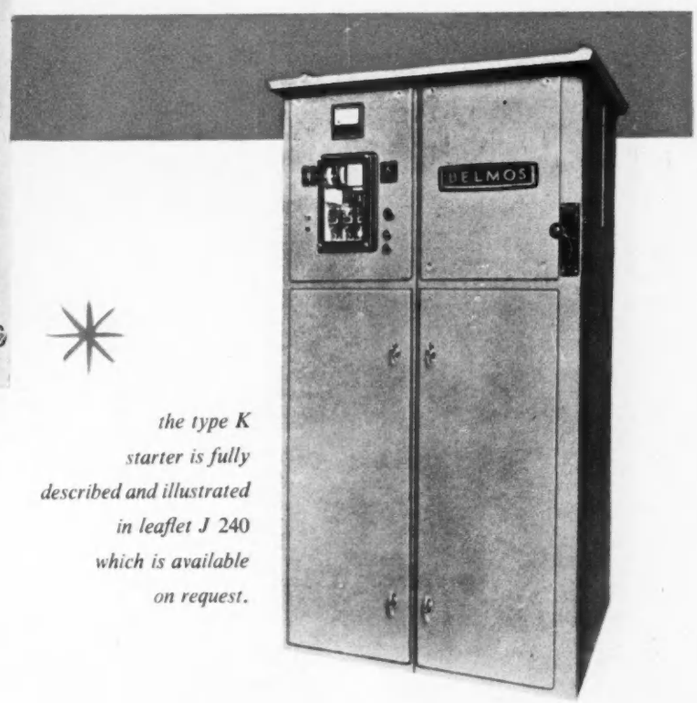

the type K starter is fully described and illustrated in leaflet J 240 which is available on request.

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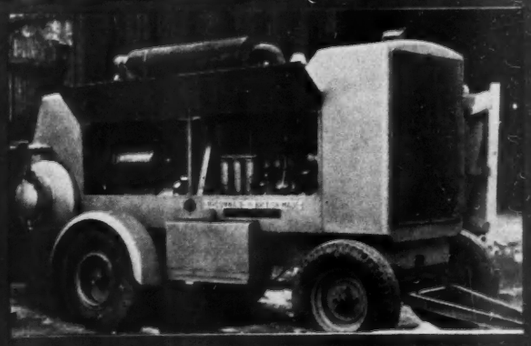

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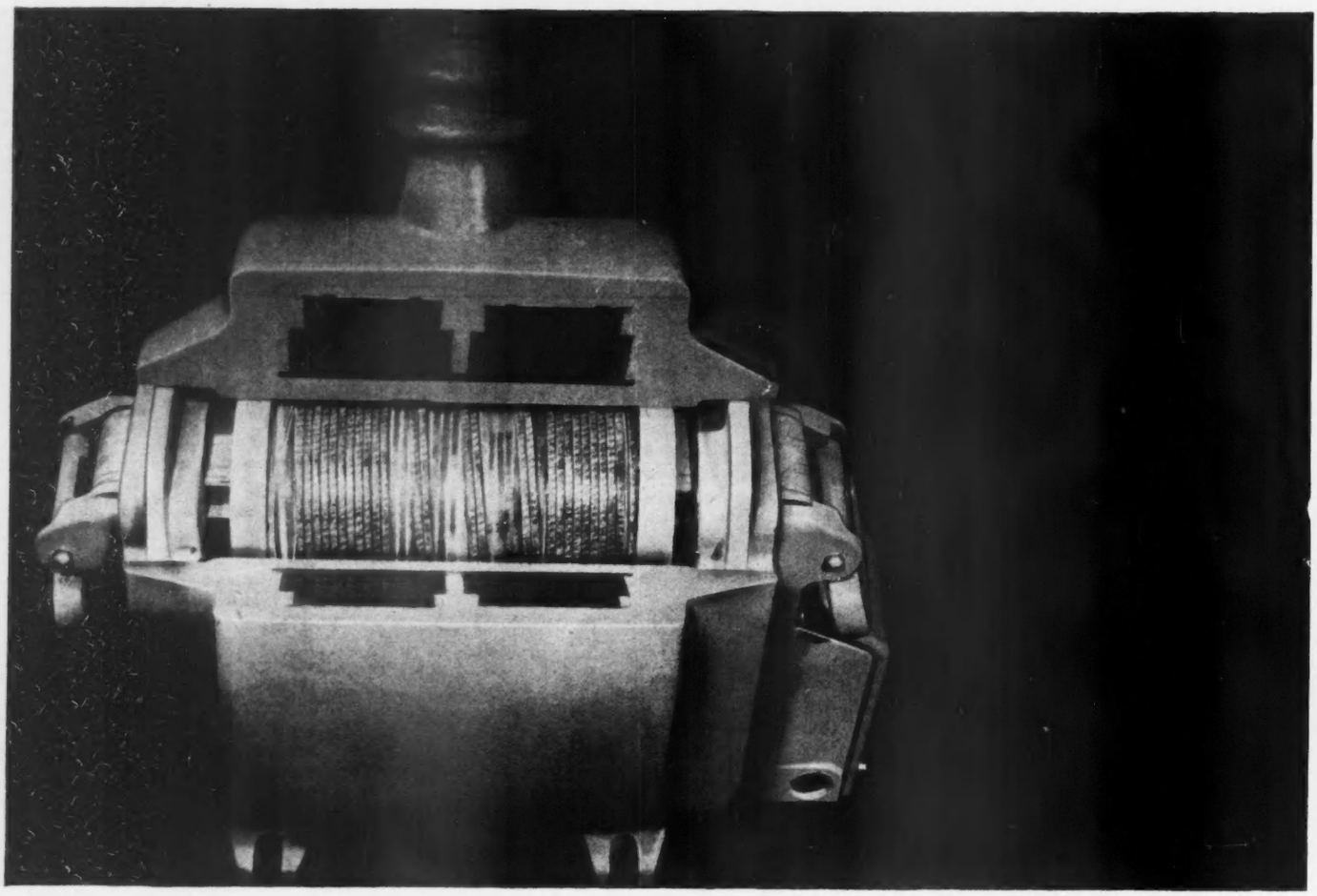

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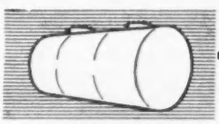
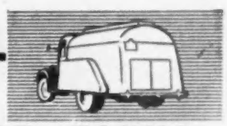

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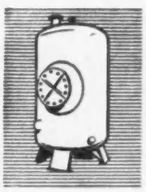

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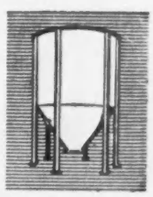

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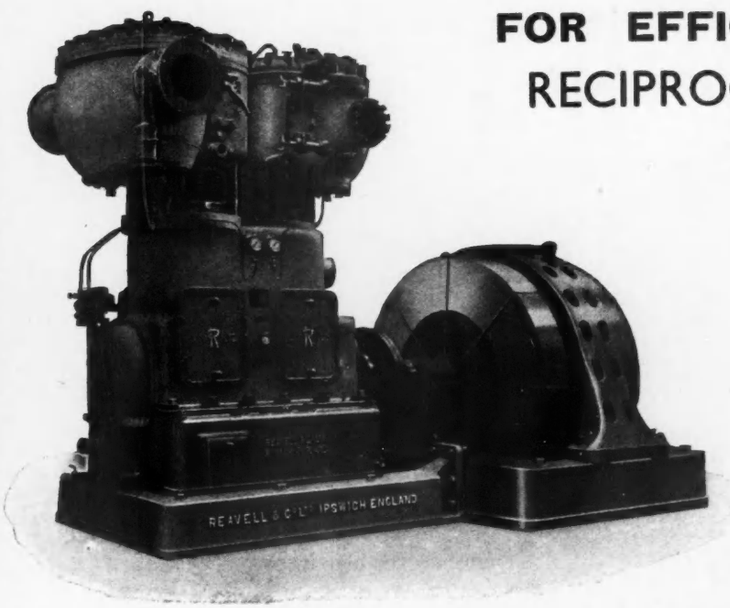

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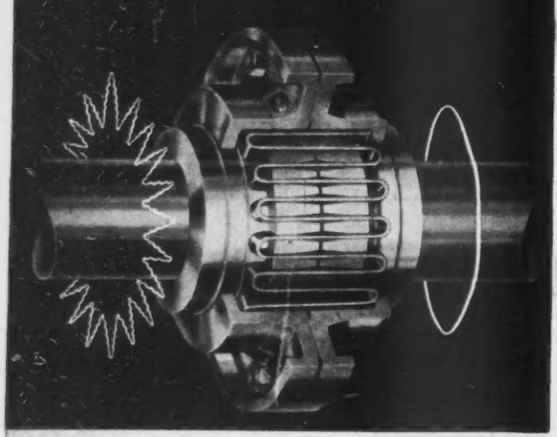

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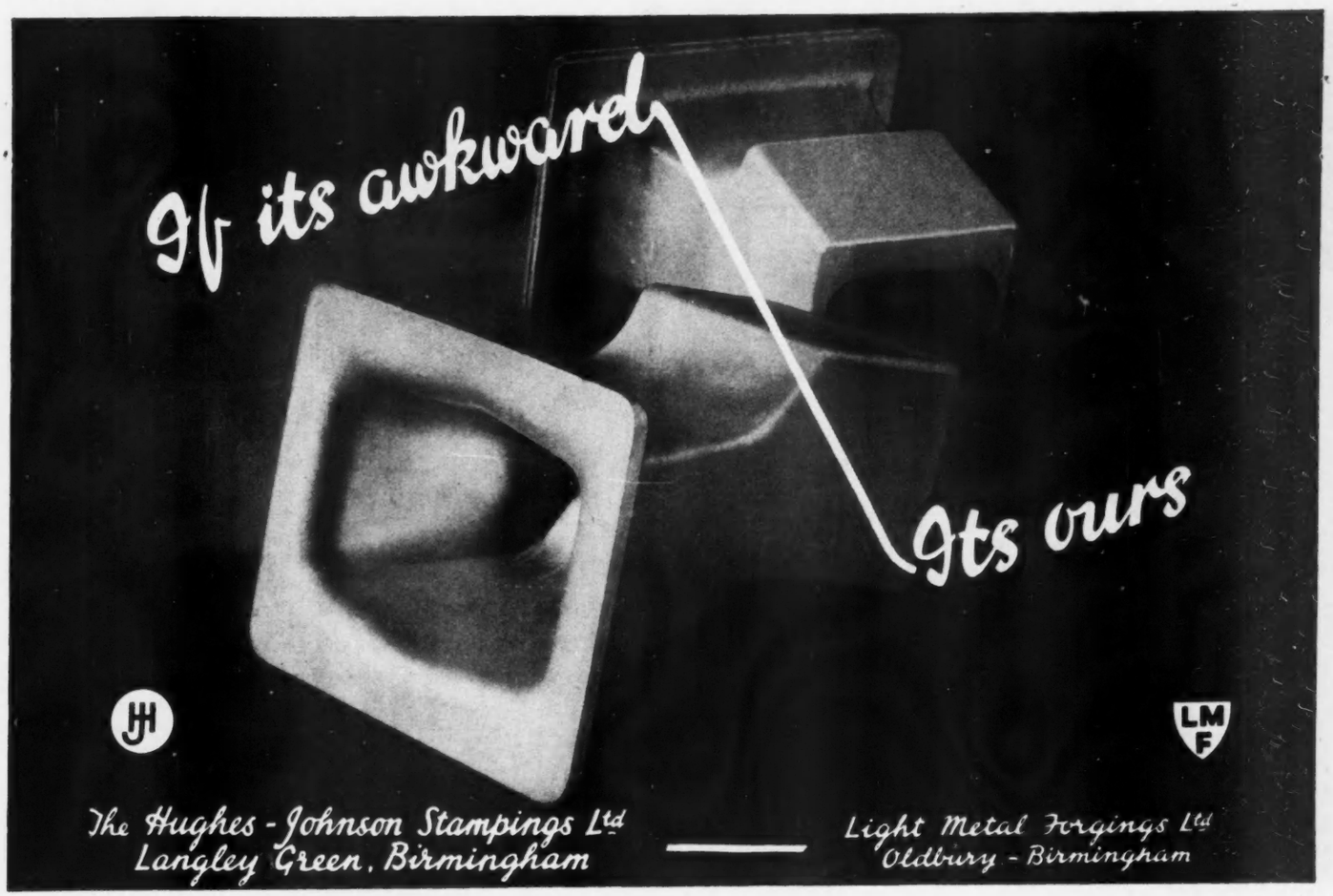

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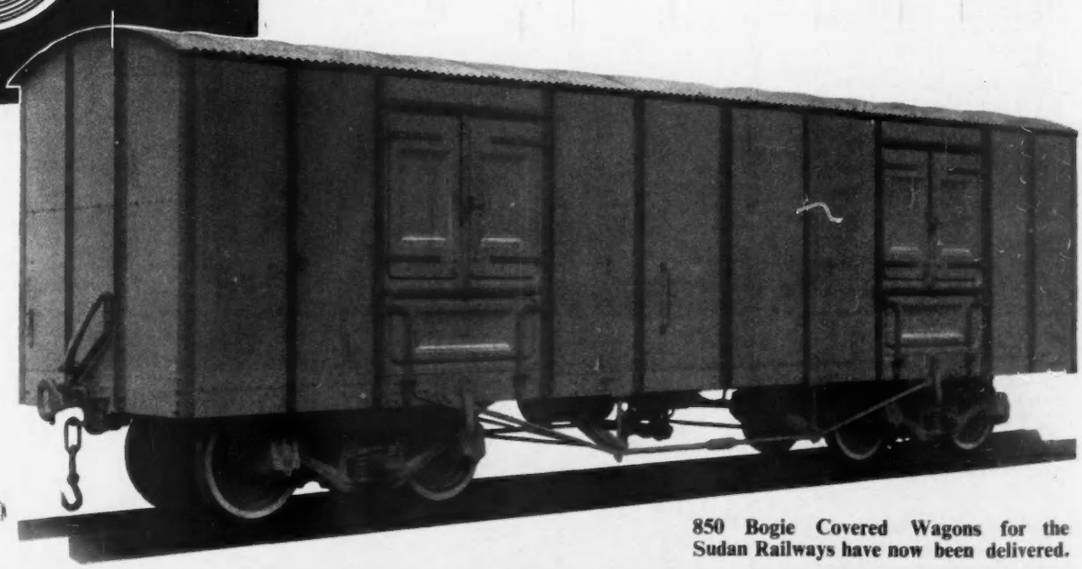

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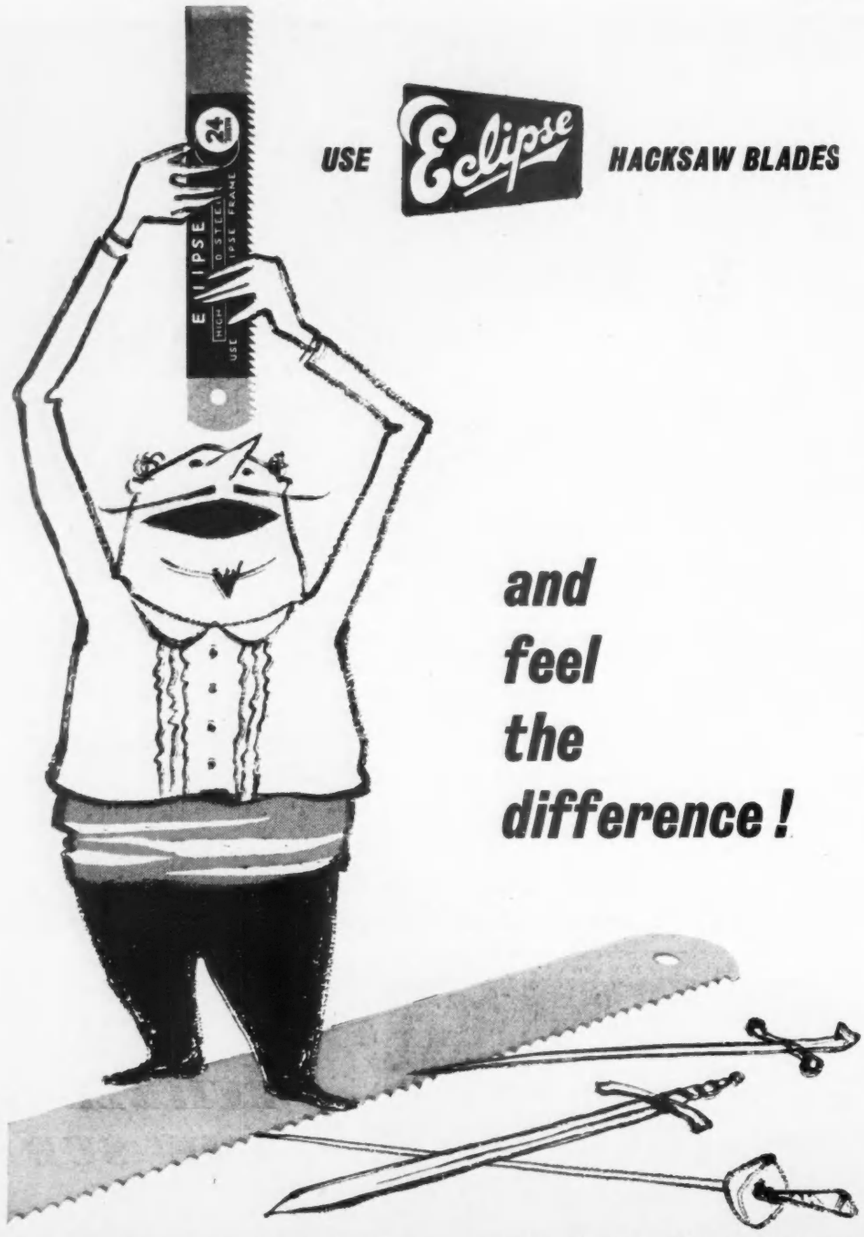

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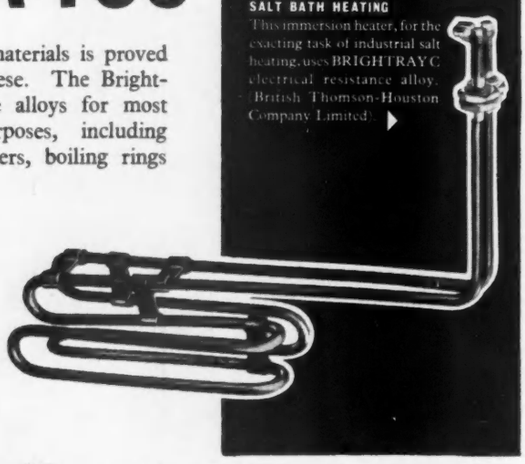

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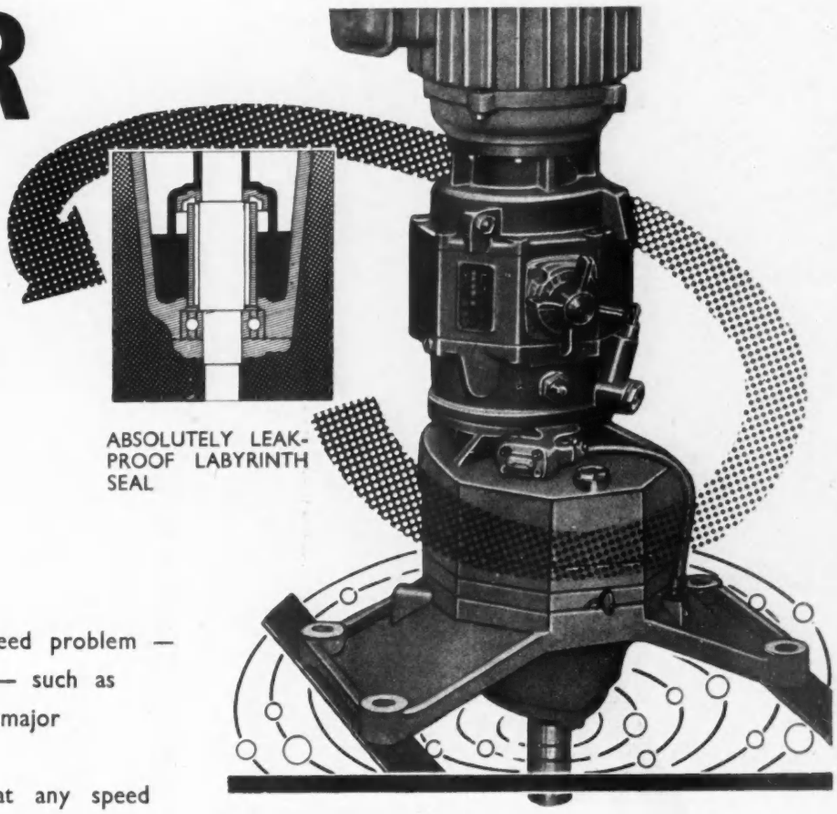

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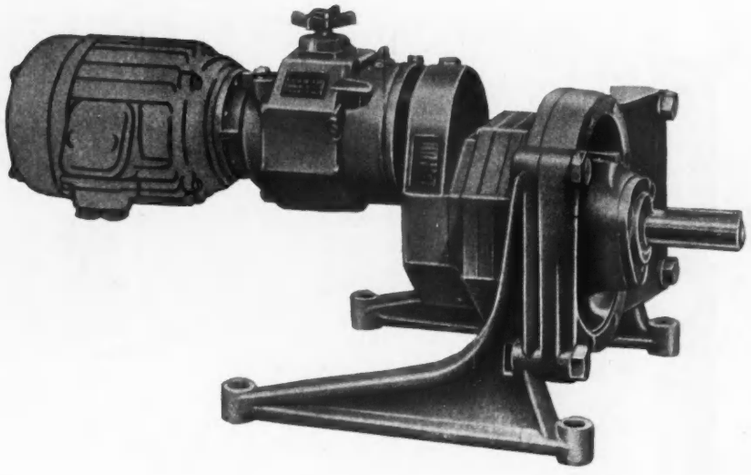

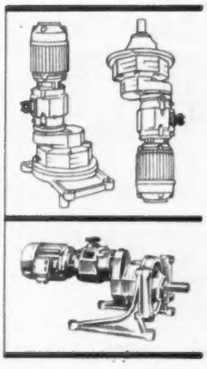

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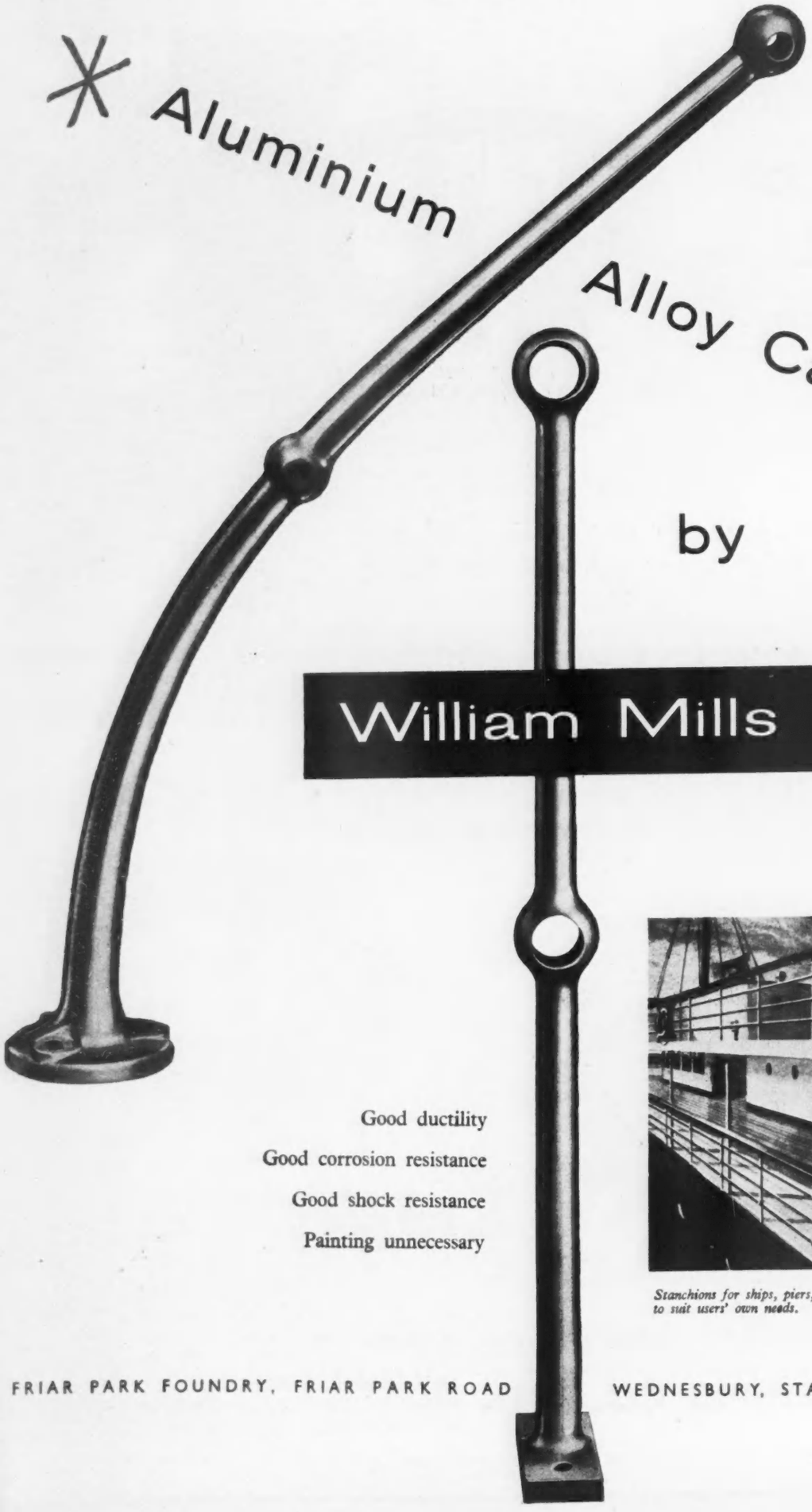

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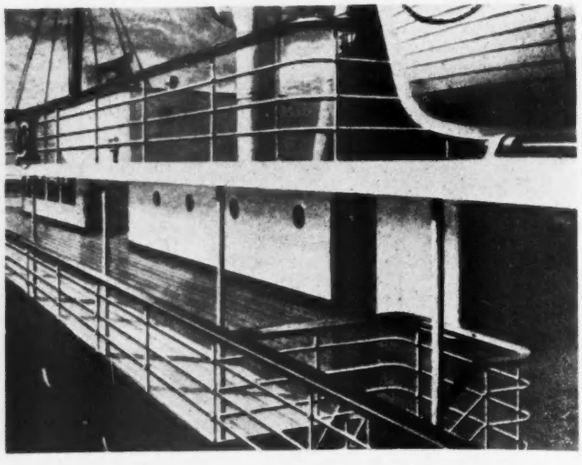

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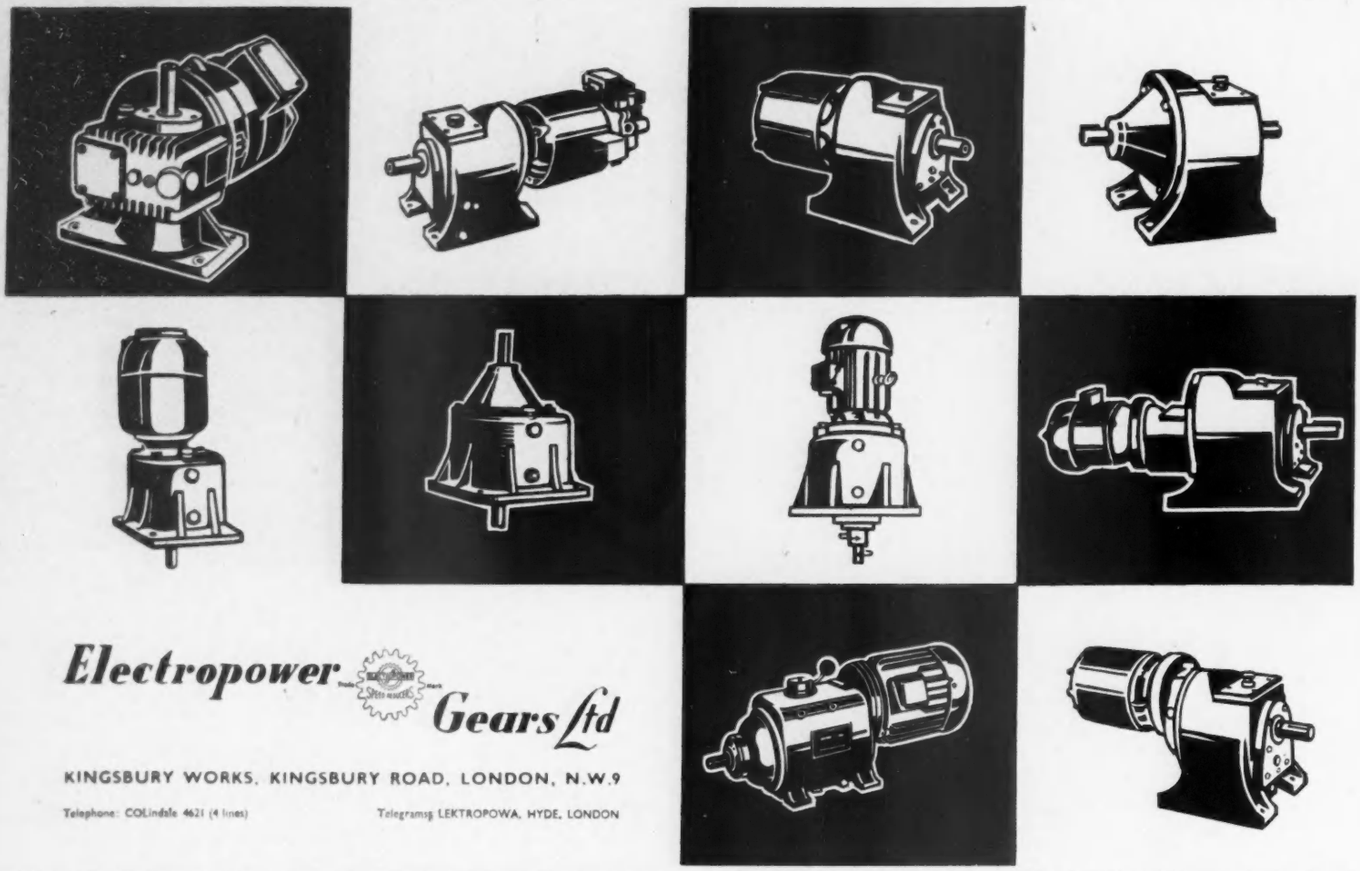

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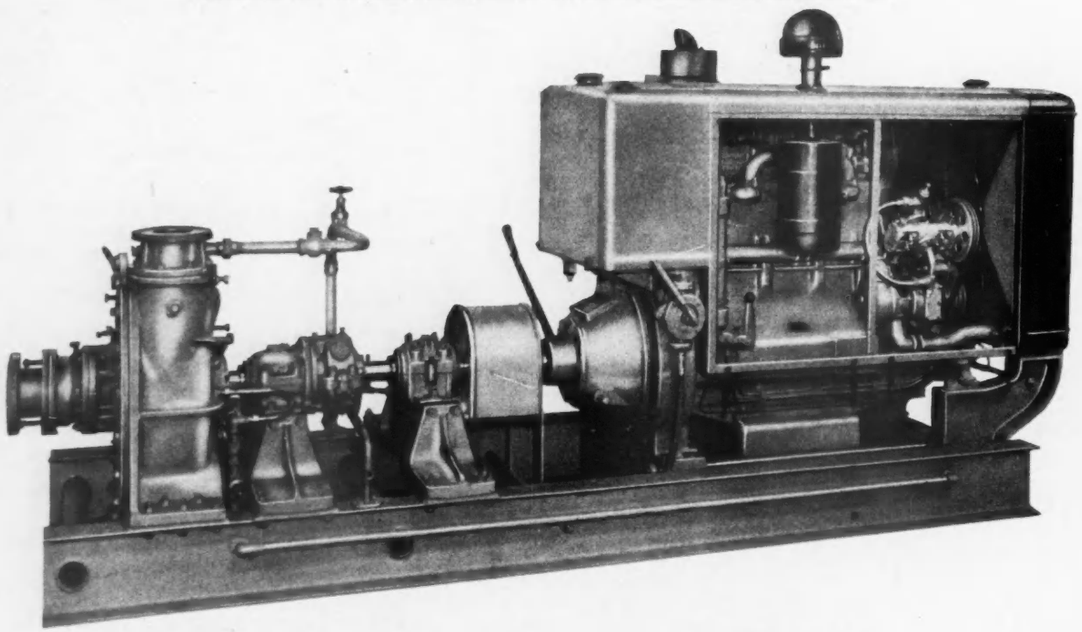

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LEWISHAM HOSPITAL

ASSISTANT ENGINEER

ASSISTANT ENGINEER required mid-September at Lewisham Hospital, S.E.13. Applicants should have completed an apprenticeship in mechanical engineering, or have otherwise acquired sound practical training. Salary according to experience within scale £575 by £25 to £700 p.a., plus London weighting (£30 at 26 and over). Long hours gratuities are also payable. A flat may be made available if necessary at a nearby hospital for which present charges amount to approximately £122 p.a. Applications, stating age, qualifications and experience, with names of two referees, to the Group Secretary at Lewisham Hospital, London, S.E.13. E7123

PUBLIC APPOINTMENTS

COLNE VALLEY WATER COMPANY

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEER

The Colne Valley Water Company invite applications for the appointment of ASSISTANT MECHANICAL AND ELECTRICAL ENGINEER.

Applicants should have a sound Mechanical and Electrical training with workshop and drawing office experience, and should preferably be Chartered Mechanical or Electrical Engineers.

The work will involve the design, installation and maintenance of pumping and treatment plant, electric generating plant and switchgear, remote control and mechanical plant.

A car allowance will be payable.

The appointment will be permanent and pensionable and the salary range will be from £1015 to £1260 per annum depending upon qualifications and experience.

Applicants should be not less than 30 years of age.

Applications should be addressed to:
John Christie, B.Sc., M.I.C.E., M.I.W.E.,
Chief Engineer,
The Colne Valley Water Company,
Aldenham Road,
Watford, Herts,
and should arrive not later than 30th September, 1959. E7127

BRIGHTON CORPORATION WATERWORKS

WATERWORKS DEPARTMENT

ASSISTANT ENGINEER

Waterworks Department have vacancies for ASSISTANT ENGINEER, Grade A.P.T. III (£880–£1065), ENGINEERING ASSISTANTS, Grade A.P.T. II (£765–£880) and Grade A.P.T. I (£610–£765).

Suitably qualified applicants should have good general waterworks experience. Appointments are superannuable, terminable by one month's notice on either side and subject to medical examination. Fifty per cent of removal expenses refunded.

Application forms from the Waterworks Engineer, 12, Bond Street, Brighton, 1, to be returned to him suitably endorsed by 5th September, 1959.

W. O. DODD,
Town Clerk.
Town Hall,
Brighton, 1. E7126

GROVE PARK HOSPITAL

ASSISTANT ENGINEER

ASSISTANT ENGINEER required from 1st October at Grove Park Hospital, Lee, S.E.12. Applications should have completed an apprenticeship in mechanical engineering, or have otherwise acquired sound practical training. Salary according to experience within scale £545 by £20 (1) by £25 (3) by £30 (1) to £670 p.a., plus London weighting (£30 at 26 and over). Long hours gratuities are also payable. Applications, stating age, qualifications and experience, with names of two referees, to the Group Secretary at Lewisham Hospital, London, S.E.13. E7124

KINGSTON GROUP HOSPITAL MANAGEMENT COMMITTEE

SENIOR ENGINEER

SENIOR ENGINEER, Kingston Hospital, Kingston-upon-Thames. Applications are invited for above appointment under direction of Superintendent Engineer from suitably qualified persons. Salary: £740 by £25 (2) by £30 (3) to £880 per annum, plus London Weighting. Residence available at reasonable rental. Candidates must have served an apprenticeship and possess a sound knowledge of the operation of steam boiler plant, oil firing, and engineering services.

Details of age, qualifications and experience, together with names of two referees, to be sent within 14 days to the Group Secretary, Kingston Group Hospital Management Committee, 35, Coombe Road, Kingston-upon-Thames, Surrey. E7101

PUBLIC APPOINTMENTS

METROPOLITAN WATER BOARD

have vacancies on the
PERMANENT STAFF
for

ASSISTANT ENGINEERS (Civil). Salary scale £980–£1210 per annum. Applicants must be corporate members of the Institution of Civil Engineers and must have had sound engineering experience.

ENGINEERING ASSISTANTS (Civil, Electrical and Mechanical). Salary scale £700 (at age 21) to £945 per annum. Applicants must have passed or be exempted from passing Parts I and II (or Sections A and B) of the examinations of the Institution of Civil Engineers, Electrical Engineers or Mechanical Engineers.

Commencing salaries according to age and experience. Good opportunities for promotion.

Housing accommodation may be available.
Five-day week: hours, 8.45 a.m. to 4.45 p.m.
Pension scheme.
Staff restaurant, sports clubs, &c.

Forms of application from the undersigned, quoting reference WE.

S. D. ASKEW,
Clerk of the Board.
New River Head,
Rosebery Avenue, E.C.1. E7084

SOUTHAMPTON CORPORATION WATERWORKS

CIVIL ENGINEERING ASSISTANT

Southampton Corporation Waterworks require CIVIL ENGINEERING ASSISTANT, age not exceeding 35. Must have passed Parts 1 and 2 Institution of Civil Engineers or exempting examination. Experience in waterworks advantageous. Salary: A.P.T. "Special Scale" (£785/£1070).

Conditions of appointment from C. A. Bradley, B.Sc., M.I.C.E., Waterworks Engineer, Civic Centre, Southampton. Applications by Monday, 31st August, 1959. E7033

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Vacancies for SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS in following localities:

LONDON AREA: MECHANICAL ENGINEER with sound knowledge of basic principles of thermo and fluid dynamics to carry out research programme in a particular field of applied hydrodynamics. Experience in modern methods of design and research on axial flow compressors, turbines or pumps an advantage. MECHANICAL ENGINEER for work on propulsion problems. APPLIED MATHEMATICIAN for research of basic nature on stability of underwater vehicles: knowledge of theoretical hydrodynamics and theory of control systems an advantage. APPLIED MATHEMATICIAN or THEORETICAL PHYSICISTS for acoustic analysis. ELECTRONIC PHYSICISTS for data handling and analysis problems. PHYSICIST interested in operator performance. CLASSICAL PHYSICISTS.

BALDOCK: PHYSICISTS or APPLIED MATHEMATICIANS for research in Metal or Quantum Physics.

PORTSMOUTH: ELECTRONIC ENGINEERS for research on analogue computers and transistor circuits. ELECTRICAL ENGINEERS for research on small rotating electrical machinery. PHYSICISTS—for optical systems and instrumentation. ELECTRO-MECHANICAL ENGINEERS — for work on servo-mechanisms.

PORTLAND: PHYSICISTS or APPLIED MATHEMATICIANS for research on underwater acoustics. ELECTRONIC PHYSICISTS, ELECTRONIC ENGINEERS—for design work. PHYSICAL CHEMISTS.

POOLE: CHEMICAL ENGINEERS. CHEMISTS for work on rubber technology.

ROSYTH: PHYSICISTS—(Electronic).

Candidates must normally be natural born British subjects of natural born British parents, with First or Second Class Hons. Degrees, S.S.Os. must have had three years' post-graduate experience and be not less than 26 years of age. Salaries (men): S.S.O., £1233–£1460; S.O., £655–£1150 (London), somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.220/9A). E7037

PUBLIC APPOINTMENTS

COLNE VALLEY WATER COMPANY

ASSISTANT PUMPING SUPERINTENDENT

The Colne Valley Water Company invite applications for the appointment of ASSISTANT PUMPING SUPERINTENDENT.

Applicants should have served a recognised apprenticeship. An O.N.C. or B.O.T. qualification is desirable.

The work will involve assisting the Pumping Superintendent in the operation and maintenance of the plant required in the pumping and treatment of water.

The appointment will be permanent and pensionable and the salary range will be from £815 to £1015 per annum depending upon qualifications and experience.

Applicants should be not less than 30 years of age.

Applications should be addressed to:
John Christie, B.Sc., M.I.C.E., M.I.W.E.,
Chief Engineer,
The Colne Valley Water Company,
Aldenham Road,
Watford, Herts,
and should arrive not later than 30th September, 1959. E7128

GROUP 25 BIRMINGHAM (SELLY OAK) HOSPITAL MANAGEMENT COMMITTEE

ENGINEER—DEPUTY SUPERINTENDENT

The Group comprises thirteen hospitals, and the post carries responsibility for acting as Deputy to the Superintendent Engineer over the whole range of his duties, including planning and maintenance of steam generating plant, heating and hot water services, and associated electrical services. Candidates must possess Higher National Certificate in Mechanical Engineering or equivalent, and must be able to draw up plans and specifications. Commencing salary, £805, rising by five annual increments to £940 per annum. No accommodation available.

Applications in writing, with names of two referees to Secretary, Group 25 Birmingham (Selly Oak) Hospital Management Committee, Oak Tree Lane, Birmingham, 29. E7100

CITY OF SHEFFIELD

APPOINTMENT OF GROUP LEADER (SURVEYOR)
GRADE A.P.T. V. SALARY £1220–£1375

Applications are invited for the above-mentioned appointment on the permanent staff of the City Architect, Mr. J. L. Womersley, F.R.I.B.A., Dist.T.P., M.T.P.I.

The successful applicant will be required to take charge of the Survey Group which is responsible for the survey and levelling of sites for all types of development carried out by the Department, the design and construction of road and sewer works, playing fields and public open spaces and the co-ordination of utility services in connection with new building work, both in the outer areas and redevelopment of the inner areas of the City.

Applicants must hold a suitable qualification and preference will be given to Chartered Civil or Municipal Engineers.

Applications, stating age, education and training, qualifications, experience, present and past appointments (with dates and salaries) and the names and addresses of persons to whom reference may be made, should reach the undersigned by Monday, 7th September, 1959.

JOHN HEYS,
Town Clerk.
6th August, 1959. E7047

TENDERS

INDIA STORE DEPARTMENT

The Director-General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the supply of:

Tender Ref. No. 18129/59/HSK/HAL.
BORING TOOL GRINDER, UNIVERSAL GRINDING MACHINE AND HORIZONTAL SPINDLE SURFACE GRINDER.

The tender forms with schedules and specifications which are returnable on 21st September, 1959, may be obtained from the above office (C.D.N. Branch) on payment of a fee of ten shillings (NOT returnable) for each tender. The applications for tenders should clearly state the above reference number. E7095

Classified Advts. continued on page 130

TENDERS

HEAVY ELECTRICALS, LIMITED, BHOPAL, INDIA

Heavy Electricals, Limited, Bhopal, India, invite TENDERS for the SUPPLY of :

1. TENDER ENQUIRY PP/FG/1 : 2-ton, 5-ton and 10-ton Cranes.
2. TENDER ENQUIRY PP/FG/2 : Elevating Trucks, Fork Lift Trucks, Fork Reach Trucks, Dump Trucks and Tractors (Electric).
3. TENDER ENQUIRY PP/FG/3 : Crane Weigher and Elevating Platform (Diesel).

Tender forms and specifications can be obtained from Heavy Electricals, Limited, Crown House, London, W.C.2, on payment of 15s. each for 1 and 2 and 7s. 6d for 3 above. Tenders are to be returned to Heavy Electricals, Ltd., Post Box No. 46, Bhopal, India, so as to reach them before 11 a.m. on 13th, 14th and 15th October, 1959, respectively. E7135

STATE ELECTRICITY COMMISSION OF VICTORIA,

22-32, WILLIAM STREET, MELBOURNE VICTORIA, AUSTRALIA

BUCKET WHEEL DREDGER—MORWELL OPEN CUT

The Commission is inviting TENDERS for the MANUFACTURE, SUPPLY, DELIVERY and ERECTION,
ALTERNATIVELY :
MANUFACTURE, SUPPLY and DELIVERY only, of :—
ONE Electrically operated BUCKET WHEEL DREDGER capable of an overall output of 1500 tons per hour, all in accordance with the terms and provisions of Specification No. 59–60/8 and B.6 ; alternatively, A.7 Contract Conditions.

Copies are available from the Agent-General for Victoria, Victoria House, Melbourne Place, Strand, London, W.C.2, and also from the Commission's Offices, 22, William Street, Melbourne, Australia.

The charge for specification is :—
£3 (returnable) for 3 sets of Tender documents. Extra copies, £1 (not returnable) per set.

Tenders endorsed "Tender to Specification No. 59–60/8," are returnable in the Tender Box, Ground Floor, 22, William Street, Melbourne, Victoria, by 11 a.m. on the 23rd December, 1959.

The Commission does not bind itself to accept the lowest or any Tender. E7104

KINGDOM OF THAILAND

ROYAL IRRIGATION DEPARTMENT, BANGKOK, THAILAND

INVITATION FOR BIDS—NO. YS-2-10

The Royal Irrigation Department of the Kingdom of Thailand hereby invites SEALED WRITTEN BIDS for FURNISHING and DELIVERING the following GOODS, EQUIPMENT, and MATERIALS either f.o.b. Contractor's shipping point or c.i.f. Bangkok Wharf, Thailand, for the Bhumiphol Dam and Power Plant, Yanhee Multipurpose Project, Kingdom of Thailand, in accordance with the Contract Documents, Invitation for Bids—No. YS–2–10, for :

Furnishing nine (9) 3·54-metre by 4·62-metre Draft Tube Bulkhead Gates and twenty-four sets of Draft Tube Gate Frames and Guides. The gate frames are to be fabricated of stainless clad plates.

Bids will be issued in late August, 1959, and will be opened in October, 1959. Copies of Contract Documents, Invitation for Bids YS–2–10, may be obtained by qualified bidders on written request on bidder's letterhead, addressed to : Royal Irrigation Department, Attention : Thai Liaison Engineer, c/o Engineering Consultants, Inc., 1940, West Mississippi Avenue, Denver 23, Colorado.

Each request must be accompanied by a cheque or money order, payable to the Royal Irrigation Department, in the amount of U.S.$10.00 for each copy of the Contract Documents requested. The remittance is non-returnable.

M. L. XUJATI KAMBHU,
Director General.

Royal Irrigation Department,
Kingdom of Thailand,
Bangkok, Thailand. E7122

WEST PENWITH RURAL DISTRICT COUNCIL

DRIFT WATERWORKS SCHEME

DISTRIBUTION SECTIONS

The Council invite FIXED PRICE TENDERS from EXPERIENCED CONTRACTORS for the following WORK. :—

CONTRACT No. 4.—The Supplying, Excavating for, Laying, Jointing, Maintenance and Ancillary Works for about 14 miles of Spun Iron Mains with Flexible Joints as follows :—

Approximately 1870 yards of 9in. diameter.
Approximately 7850 yards of 8in. diameter.
Approximately 4970 yards of 6in. diameter.
Approximately 3500 yards of 4in. diameter.
Approximately 6600 yards of 3in. diameter.

The general conditions, specification, bill of quantities and form of Tender for this contract, prepared by the Engineers, Herbert Lapworth Partners, 25, Victoria Street, Westminster, S.W.1, may be obtained from the undersigned on or after Monday, 7th September, 1959, on receipt of a cheque for £5 0s. 0d., made payable to the West Penwith Rural District Council, which sum will be returned on receipt of a bona-fide Tender.

Tenders, together with all documents received, are to be enclosed in a sealed cover endorsed "Drift Water Scheme—Tender for Contract No. 4—Pipe-laying," and addressed to the undersigned and delivered not later than 10 a.m. on Monday, 5th October, 1959.

Only Tenders from firms experienced in this type of work will be considered.

The Council do not bind themselves to accept the lowest or any Tender.

H. M. W. MOORE,
Clerk of the Council.

38, Chapel Street,
Penzance, Cornwall.
17th August, 1959. E7136

TENDERS

KINGDOM OF THAILAND

ROYAL IRRIGATION DEPARTMENT, BANGKOK, THAILAND

INVITATION FOR BIDS—NO. YS-2-11

The Royal Irrigation Department of the Kingdom of Thailand hereby invites SEALED WRITTEN BIDS for FURNISHING and DELIVERING the following GOODS, EQUIPMENT, and MATERIALS, either f.o.b. Contractor's shipping point or c.i.f. Bangkok Wharf, Thailand, for the Bhumiphol Dam and Power Plant, Yanhee Multipurpose Project, Kingdom of Thailand, n accordance with the Contract Documents, Invitation for Bids—No. YS–2–11, for :

Furnishing two (2) 2·136-metre (84-inch) Free Discharge Valves, complete with operating mechanism, and appurtenant accessories to operate under a maximum static head of 120 metres (393 feet). The valves shall be of the hollow-cone or hollow-jet type.

Bids will be issued in August, 1959, and will be opened in October, 1959. Copies of Contract Documents, Invitation for Bids YS–2–11 may be obtained by qualified bidders on written request on bidder's letterhead, addressed to : Royal Irrigation Department, Attention : Thai Liaison Engineer, c/o Engineering Consultants, Inc., Denver 23, Colorado.

Each request must be accompanied by a cheque or money order, payable to the Royal Irrigation Department, in the amount of U.S.10.00 for each copy of the Contract Documents requested. The remittance is non-returnable.

M. L. XUJATI KAMBHU,
Director General.

Royal Irrigation Department,
Kingdom of Thailand,
Bangkok, Thailand. E7121

CITY AND COUNTY OF BRISTOL

MAIN FOUL WATER DRAINAGE SCHEME

MAIN PUMPING STATION

Experienced manufacturers of Propeller Pumps, Motors and Ancillary Equipment are invited to APPLY FOR INCLUSION in a selected list of firms who will be invited to TENDER for the SUPPLY and ERECTION of AUTOMATIC PUMPING PLANT for the above.

Six pumps will be required in the first instance, each to discharge about 20,000 gallons per minute against a mean total static head of about 27ft. Two of the pumps will be equipped with variable pitch impellers and the sewage will pass through comminutors or screens prior to pumping.

Applications, with supporting evidence of similar experience, to City Engineer and Planning Officer, Cabot House, Deanery Road, Bristol, 1, by 28th August. E7057

INDIA SUPPLY MISSION

The Office of India Supply Mission, 2536, Massachusetts Avenue, N.W. Washington 8, D.C., U.S.A., invites TENDERS for the following :

Item	Description	Specification No.
1.	Water tube boilers, 80,000 lbs./hr.	CH-2
2.	Steam Turbo Alternator, 10,000k W	CH-3
3.	Overhead turbine-house crane	CH-4
4.	Broad gauge side wagon tippler	CH-5
5.	Shunting Diesel Locomotives	CH-6
6.	6·9kV and 440V Switchgear and accessories	CH-7
7.	Cooling tower equipment	CH-8

Tender forms and specifications relative to the above can be obtained from Co-Ordination Branch, India Store Department, Bromyard Avenue, Acton, London, W.3, at a cost of 14 shillings and 3 pence for conditions of contract and tender form, plus £1 15s. 8d. per set of specifications for each item which is not refundable. Tenders are to be returned direct to India Supply Mission, Washington, U.S.A., so as to reach them by the 27th October, 1959.

Specimen copy of the above enquiry can be seen at Engineering Branch, India Store Department, Bromyard Avenue, Acton, W.3 under reference No. S.3297/59/ENG.2. E7096

EDUCATIONAL

UNIVERSITY OF MANCHESTER

THE NEXT SESSION COMMENCES ON TUESDAY, 13th OCTOBER, 1959. E7029 E

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

ELECTRONICS, covering practical and theoretical aspects, basic principles, Industrial applications, electronic apparatus, &c. Guaranteed coaching for Brit.I.R.E., City and Guilds, &c. Study at home under highly qualified tutors.—Write for free book : International Correspondence Schools, 71, Kingsway (Dept. 446A), London, W.C.2. E157 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

ASSISTANT WORKS MANAGER. The successful applicant will have had varied experience in light engineering, M/C shop, press shop and small mechanisms assembly, be a keen disciplinarian and able to control a labour force of several hundred. Only those who possess the initiative, drive and personality to fill this post, which carries a good salary and prospects with pension entitlements, should write, giving full particulars, to Personnel Manager, Roneo, Limited, Romford, Essex. E6997 A

SITUATIONS VACANT

ASSISTANT WORKS ENGINEER required for Chemical Manufacturers in East London area. Technical training to H.N.C. standard. Chemical works experience is essential. Age preferred between 28–33 years. Salary according to experience. Pension scheme.—BOX No. E7111, "The Engineer." A

BP invites applications from GRADUATES aged 23–26 years with an Honours Degree in Petroleum Engineering, Engineering or Physics for employment as PETROLEUM ENGINEERS in TRINIDAD in the first instance. Duties will consist in assisting in all aspects of field production work, including well control, artificial lift, gas control, oil collection and well servicing. National Service obligations must have been fulfilled.—Write, stating age and full details of qualifications and experience, quoting F.574, to BOX 3174, c/o 191, Gresham House, E.C.2. E7142 A

BRONX ENGINEERING COMPANY, LTD., DUDLEY ROAD, LYE, have the following vacancies in their Machine and Tool Design Offices :

(a) SENIOR DESIGNER with design experience of auxiliary machines for Ferrous and Non-Ferrous Sheet and Tube Mills. For this responsible position comprehensive experience of special purpose machinery design and a good technical standard coupled with a high sense of personal responsibility are essential.
(b) SENIOR AND INTERMEDIATE DESIGNERS for the Tool Design Office. Experience of tool design in the field of Press Brake Work would be the prime qualification, but men having a good technical and practical training combined with drive, initiative and the ability to work as a member of a small highly skilled and enthusiastic team could qualify.
(c) INTERMEDIATE DRAUGHTSMEN with good practical and technical qualifications preferable with experience of detail design of special purpose machines. This is an excellent opportunity for young men of considerable ability to further their career by working with a team of highly specialised designers.

REPLIES, STATING QUALIFICATIONS (which will be treated in the strictest confidence) should be addressed to :
THE CHIEF DESIGNER, BRONX ENGINEERING COMPANY, LTD., DUDLEY ROAD, LYE, Near Stourbridge, Worcs. A7083 A

DESIGN ENGINEERS H.N.C. (MIN) required. Experience in one or more of the following essential: Cranes, Excavators, Truck Mounted Mobile Cranes and Contractors Plant. Good staff conditions. Pension scheme. Application in writing, all relevant particulars and approximate salary required to:—Personnel Manager, RUSTON-BUCYRUS LTD., Excavator Works, Lincoln. E6960

DESIGN ENGINEER required with experience in heat transfer calculations and design of small compac heat exchangers.—Write, stating age, details of experience, &c., to Chief Designer, Delaney Gallay, Ltd., Vulcan Works, Edgware Road, Cricklewood, N.W.2. GLAdstone 2201. E7097 A

DESIGNER-DRAUGHTSMAN required, preferably with H.N.C. in Mechanical Engineering. Non-contributory pension scheme available.—Applications to Metalectric Furnaces, Ltd., Cornwall Road, Smethwick, 40, Staffs. E2512 A

DEVELOPMENT MANAGER

required by Raleigh Industries, Limited, in Nottingham, to assume responsibility for :

1. Development of New Manufacturing and Finishing Processes and New Products ;
2. Product Testing ;
3. Experimental Machine Shop and Prototype Building,

in return for a very good, four-figure, salary.

A research graduate, preferably from a University where the first Degree course is a general course in all branches of engineering, preferred. An Honours Degree in Mechanical Engineering and A.M.I.Mech.E. essential.

Men, aged 35–45, with education specified above, and with wide experience in design, production methods and development work in light engineering and with proved and successful leadership of a design and development team, are invited to write to the Personnel Executive, 177, Lenton Boulevard, Nottingham, giving full particulars of education, qualifications, age and experience. E7147 A

DRAUGHTSMAN required. Experience in mechanical handling plant and structures an advantage. Good prospects.—British Industrial Sand, Ltd., High Street, Godstone, Surrey. E161 A

ENGINEER, experienced dust collection problems, capable handling schemes from inquiry to completion.—Write, stating experience, age, salary required, The Visco Engineering Co., Ltd., Stafford Road, Croydon. E7015 A

ENGINEER, experienced modern air-conditioning and ventilating plant. Able to handle complete schemes from inquiry to completion on own initiative. —Write, stating age, qualifications, salary required, to The Visco Engineering Co., Ltd., Stafford Road, Croydon. E7016 A

ENGINEER SURVEYOR required for Inspection of Cranes and other Lifting Plant. Must have Drawing Office experience in design of Cranes and National Certificate of Mechanical Engineering. Resident south preferably near London for relief work. Commencing salary £800 rising to £1100 (ESA Scale). Pension and other benefits.—Apply Eng. Dept., GENERAL ASSURANCE CORP., 99, Aldwych, London, W.C.2. E7115 A

ESTIMATING ENGINEER required for Oil Refinery and Chemical Plant Contractors. Applicants must have drawing-office experience and wide knowledge of refinery layout ; must also be capable of working to preliminary plot plans and flow sheets. Minimum standard of education ; H.N.C. or equivalent.—Write fully, stating age and experience Staff Manager, Foster Wheeler, Ltd., 3, Ixworth Place, London, S.W.3. E7094 A

SITUATIONS VACANT

ENGINEER (qualified) for Near East, having considerable experience pipeline, pump station and tank farm construction.—Write fully, stating age, qualifications and experience to BOX No. 2745, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E7093 A

ENGINEER required with exempting qualifications for Corporate Membership of the Institutions of Mechanical Engineers/Electrical Engineers, to undertake the duties of an ASSISTANT MAINTENANCE ENGINEER in a highly mechanised tube works. The post is progressive and can best be filled by a young man, age 27/30, who has had previous experience in the control of labour engaged in plant repair and preventive maintenance.—Applications, stating salary expected, should be made to the Works Director, Tubes Limited, Eagle Works, Kirby Muxloe, Leicester. E7052 A

ENGINEER
required by
THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE

To act as a SECTION ENGINEER in an engineering services organisation. He will be responsible for initiation and execution of all maintenance work and minor new works projects within a group containing a number of large research laboratories and manufacturing workshops. The laboratories contain complex equipment for metallurgical and chemical processing and for machining a variety of radio-active and toxic materials. Some laboratories are engaged on fundamental nuclear research and the equipment used includes research reactors and accelerators including High and Medium Voltage electrical research equipment. Additionally, he is responsible for the 24-hour operation of associated plant which may include large air conditioning installations, refrigeration plant, gas handling plant, &c.

A recognised engineering apprenticeship is required and Corporate Membership of a Senior Engineering Institution or equivalent qualifications. A good general engineering training and some works engineering experience on the maintenance of chemical process plant or heavy mechanical and electrical plant is necessary.
Salary : £1345–£1800.

Contributory Superannuation Scheme. A house or substantial assistance with house purchase will become available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at above address. Please quote ref. 2356/25. E7088 A

ENGINEER (about 30 years) required for Consulting Engineer's office in Cardiff. Engineering Degree and/or Corporate Membership of a Senior Engineering Institution ; varied industrial experience an advantage. Technical investigations and reports in matters where litigation is being considered.—BOX No. E7103, "The Engineer." A

ENGINEERING COMPANY IN WEST AFRICA importing Electrical Machinery and Equipment manufactured by firm of world-wide repute requires an ENGINEER capable of developing the sales of these products in a rapidly expanding market. Applicants, who should be under 35, must have had experience in the selling field backed by a wide practical experience. Qualifications should be at least to H.N.C. Commencing salary will be £1200 per annum or more depending on qualifications. In addition there are family allowances, free furnished accommodation, free passages to and from Africa, and free medical attention in Africa. Tours are about 21 months followed by substantial leave on full pay, membership of Pension Fund.—Apply, giving full details of experience and qualifications to BOX No. E7119, "The Engineer." A

ENGINEERING DRAUGHTSMAN (MECH:) H.N.C. Standard required to act as Supervisor of Apprentice training in drawing office of large excavator manufacturers. Knowledge of Cranes, Excavators or Contractors Plant helpful but not absolutely essential if possessing genuine intereat in young persons. Good staff conditions. Pension Scheme. Application in writing, all relevant particulars and approximate salary required to: Personnel Manager, RUSTON-BUCYRUS LTD., Excavator Works, Lincoln. E6959

EXPERIENCED TECHNICAL SALES ENGINEER required by British Merchant House in Khartoum, Sudan. Must be able to conduct own correspondence and negotiations with Principals and clients, and be willing travel throughout the territory. Preference to applicants with good experience of diesel engines, pumps, oil mills, &c., and with experience of electrical equipment and air conditioning and able to estimate projects and prepare simple drawings. Free air passages, furnished accommodation at nominal rent, non-contributory pension scheme, annual home leave on full pay after two years' service.—Write Personnel Officer, Mitchell Cotts Group, Ltd., Cotts House, Camomile Street, London, E.C.3. E7134 A

EXPERIENCED QUALIFIED MECHANICAL ENGINEER wanted to fill the position of WORKS ENGINEER in rapidly expanding processing factory in the Hull Area. The Works Engineer will be responsible for all engineering matters, including maintenance, re-organisation of Plant and erection of New Plant. He will be expected to actively participate in development work connected with new processes.—BOX No. E7069, "The Engineer." A

INTERMEDIATE DRAUGHTSMEN required for well established and progressive West of England engineering firm producing high quality pumps. State qualifications and salary required.—BOX No. E7131, "The Engineer." A

KODAK, LIMITED, HARROW.—Applications are invited from men up to 25 with knowledge of structural and mechanical engineering and qualifications in either. The work concerns the design of darkrooms and photographic workrooms, the installation of photographic printing and processing equipment, and visits to customers' premises on these aspects. Photographic knowledge would therefore be an asset.—Please apply in writing, giving details of qualifications and experience, to the Personnel Manager (Department 125). E7143 A

SITUATIONS VACANT

HICK, HARGREAVES AND CO., LTD., SOHO IRONWORKS, BOLTON,
have vacancies for
SENIOR MECHANICAL ENGINEERING DRAUGHTSMEN
for interesting work on large Power Station condensing and feed heating plant. Experience in this type of work is desirable but not essential. Candidates with H.N.C. or equal will be preferred. Practical experience is essential, together with a sound knowledge of pressure vessels and piping layouts.
Pension Scheme carrying free insurance.
Good canteen facilities.
Five-day week.
Applications, stating details of age, experience and salary expected, should be addressed to the CHIEF DRAUGHTSMAN.
E2509 A

MECHANICAL ENGINEER with some electrical knowledge required to join a group engaged on design and Site Supervision of oil products pipeline and distribution depots in Iran. Knowledge of petroleum practice is essential. Applicants should be aged about 35 years and have design experience of pumping and ancillary equipment. Applicant will be required to work in London in the first instance.—Send fullest particulars to Staff Office, Rendel, Palmer and Tritton, Consulting Engineers, 125, Victoria Street, London, S.W.1. E7050 A

MECHANICAL ENGINEER required to assist in the development of special purpose machinery in connection with the manufacture of sensitised photographic materials. Applicants, with H.N.C. as a minimum qualification, should write in the first instance, giving all relevant particulars in chronological order, to the Chief Development Engineer, Ilford Limited, Central Engineering Department, Roden Street, Ilford, Essex. E7110 A

MECHANICAL ENGINEERS (LONDON)—old-established with well-equipped Machine, Coppersmithing, Plating and Welding Shops producing specialised Machinery, Copper and Stainless Steel Vessels and Conveyor Plant require Experienced **ESTIMATING ENGINEER** capable of taking charge of Department. Varied and interesting work. Shop training essential. Age 30 to 50. Good salary to right man. Pension Scheme.—Reply with full details of experience as well as technical education to BOX No. E7140, "The Engineer." A

METALLURGIST, special steel and foundry experience as sales representative. Prepared to travel abroad. German and French desirable.—BOX No. E2510, "The Engineer." A

RALEIGH INDUSTRIES, LIMITED,
NOTTINGHAM
offer a number of SENIOR and JUNIOR APPOINTMENTS for qualified ENGINEERS and TECHNOLOGISTS to be engaged upon an expanding programme of interesting and important new projects. A high standard of initiative and technological ability is required; the minimum qualification required in each case is a University Degree or H.N.C. in the appropriate subjects. Salaries will be offered which are appropriate to qualifications and experience. Conditions, prospects and opportunities are good.
Applications are invited for situations in the following categories:
SENIOR PROJECT DESIGNERS AND DESIGNER/DRAUGHTSMEN for
(a) Design, Development and Manufacture of Motorised vehicles.
(b) Design, Development and Manufacture of new ranges of Juvenile cycles.
(c) Design, Development and Manufacture of Electro-mechanical vehicular equipment.
SENIOR AND JUNIOR DEVELOPMENT ENGINEERS for
(a) Development of new manufacturing methods and processes.
(b) Product Testing and Experimental work.
SENIOR METALLURGISTS for
(a) Development of new manufacturing methods and Finishing Processes.
(b) Control of works manufacturing, Heat Treatment and Finishing Processes.
(c) Product Testing and Experimental work.
Apply, in writing, to the Personnel Executive, 177, Lenton Boulevard, Nottingham, giving full particulars of Education, Qualifications, Age and Experience.
E7146 A

SCIENTIFIC TECHNICAL OFFICERS required at the National Coal Board Mining Research Establishment, Worton Hall, Isleworth, Middlesex, to assist in the design and development of electrical and electronic instruments for use in the laboratory and also in the mines. The work ranges from the design of individual measuring units to the full-scale instrumentation of modern mining machines and includes transistor techniques. H.N.C./O.N.C. in Electrical Engineering or equivalent is required. Appointment superannuable and salary according to qualifications and experience within £1010–£1168, £700–£936, £557–£725.—Write for application form to the Personnel Officer (X.1407/3F) at the above address, which should be returned by 3rd September, 1959. E7132 A

SENIOR DETAIL DRAUGHTSMAN, O.N.C. (MIN) required. Experience in one or more of the following essential: Cranes, Excavators, Truck Mounted Mobile Cranes and Contractors Plant. Good staff conditions. Pension Scheme. Applications in writing, all relevant particulars and approximate salary required to: Personnel Manager, Ruston-Bucyrus Ltd., Excavator Works Lincoln.
E6961

SENIOR DRAUGHTSMAN, experienced, is required by a large Midland Steel Works for essential design work. Knowledge of steel works mechanical engineering desirable but not essential. Applicants should hold H.N.C. or similar qualification. Pension scheme, free life assurance and canteen facilities are provided.—Apply stating age, and giving full details of experience and salary required to the Chief Engineer, BOX No. E7141, "The Engineer." A

SALES ENGINEER required for London Office of rotary printing machine manufacturers. Applicants must have good technical, practical and, preferably also, selling experience of rotaries, and be capable of analysing printers' requirements and promoting sales of new types of machinery. Preferably 30/40 years of age, and possess technical qualification comparable to A.M.I.M.E. A progressive opportunity and a pensionable post. Reply, stating age, chronological details of experience and salary required, to Managing Director.—BOX No. E7028, "The Engineer." A

SUTCLIFFE HYDRAULICS, LTD., require a DRAUGHTSMAN with good experience of hydraulic work. O.N.C. desirable. A generous salary is payable and the Company has a pension and life assurance scheme.—Write in the first instance, giving details of experience and training, to the General Manager, Sutcliffe Hydraulics, Ltd., Speedwell Works, Whitwood, Castleford, Yorkshire.
E7137 A

SENIOR ENGINEER
HEAD OF WORKS SERVICES
required at the National Coal Board's Central Engineering Establishment, Stanhope Bretby, Nr. Burton-on-Trent. He will be responsible for all operational services at the Establishments, and for the development and maintenance of its capital resources and testing sites. These responsibilities include the Workshops, which are equipped to carry out repairs and assist in the manufacture of rigs and equipment needed by the Development or Proving Programme, the provision and management of works and site services, including building and civil maintenance, electrical and instrument workshops, and all industrial labour. Candidates should be corporate members of one of the senior engineering Institutions or possess equivalent qualifications, and should have a wide operational engineering experience in the fields indicated, including the control of labour. Appointment superannuable, and salary according to qualifications and experience within £1800–£2450.—Write with full details to Staff Department (X1512F), National Coal Board, Hobart House, London, S.W.1.
E7087 A

SOUTH EASTERN GAS BOARD.—ENGINEERS and CHEMISTS required for new Gas from Oil Plant at Isle of Grain, Kent. Interesting and well-paid positions are available to Engineers and Chemists at the South Eastern Gas Board's new oil gasification plant at the Isle of Grain, where important developments are taking place. Applications are invited from Engineers and Chemists with suitable engineering or chemical qualifications and experience for the following appointments: Process Engineers, £1155–£1355 per annum, rising to £1533 per annum; Shift Engineers, £1006 '£1235 per annum; Shift Supervisors, £946–£1071 per annum; Chemists, £902–£1131 per annum; Assistant Chemists, £664–£927 per annum. Four Process Engineers will be required to control each of the following sections of plant: (1) the production and treatment of gas made in Segas plants; (2) the operation of high pressure gasification and treatment plant; (3) the manufacture of oxygen; (4) the operation of high pressure boilers, electrical generators and other ancillary power plant. Shift Engineers will be responsible to the Station Engineer for the general operation of the Works during their shift and will be assisted in their duties by the Shift Supervisors. The Chemists will be required to cover all aspects of the chemical control of plant. Successful applicants will be trained where necessary in the operation of oxygen plant, high pressure gasification plant and ancillary processes. The Board will give assistance in connection with housing accommodation.—Applications, quoting reference V14/1085, should be addressed to the Personnel Manager, South Eastern Gas Board, Katharine Street, Croydon, Surrey, within seven days. Applicants should state clearly for which of the above vacancies they wish to be considered.
E7106 A

STRUCTURAL DESIGNER required for work on important and interesting structures of steel lattice construction. Qualifications at least to H.N.C. and good experience in steel construction essential. Age 23 to 27.—Apply, giving all details and salary required to Personnel Officer (Staff), British Insulated Callender's Construction Company, Ltd., 21, Bloomsbury Street, London, W.C.1.
E7139 A

THE GLACIER METAL COMPANY, LTD.
Invites Applications for the Post of
SENIOR RESEARCH ENGINEER
The successful candidate will work solely for the Manager of the Engineering Research Department in the Company's Research and Development Organisation. He will be responsible for keeping abreast of work carried out externally in the field of fundamental research in plain bearings and bearing applications: he will assist his Manager in assessing the commercial and research implications of application data and also carry out original research in this field: he will have to build up and lead a small team of research workers for this purpose. There are excellent career prospects.
Applicants should have an Honours Degree in Mechanical Engineering together with some practical experience and at least two years research, preferably of course, though not essentially, in the field of sliding bearings or lubrication.
Salary Range: £1350 to £1750 per annum.
Applications should be sent to
Personnel Director (Ref. ERD),
Glacier Metal Company, Ltd.,
Ealing Road, Alperton, Wembley, Middx.
E7080 A

TECHNICAL REPRESENTATIVE required by large mechanical handling firm: area London and Home Counties. Experience in both package and bulk handling essential. Sales contacts in area desirable. Salary and expenses; car provided.—Reply in writing to New Conveyor Co., Ltd., 9, Cork Street, London, W.1. E7112 A

THE WELLCOME FOUNDATION, LTD. require an ENGINEER who will be responsible to the Chief Engineer for factory development in overseas associated companies in the Group. Although normally located at the Wellcome Chemical Works, Dartford, he must be willing to travel and to accept assignments necessitating temporary residence abroad. The position offers considerable scope for initiative and candidates should have industrial experience and be members of the Institution of Mechanical Engineers. Salary will be in accordance with qualifications and experience. Contributory Pension Scheme and excellent staff conditions.—Applications should be sent to the Personnel Manager, Wellcome Chemical Works, Dartford, Kent. E7130 A

TUBE TRADE (STEEL) WORKS MANAGER required for medium-sized private company in the Birmingham area. Previous experience should cover low and high carbon steels, hot rolling, cold drawing, welded tubes and production control. Vacancy occurs owing to ill-health of present occupant.—Reply briefly in writing when reply form will be sent. Strictest confidence observed.—BOX No. E7070, "The Engineer." A

TURBOCHARGER ENGINEERS required for rapidly expanding department of engine accessory manufacturers. Preferably a Graduate, but experience in diesel development essential, together with the ability to discuss design and application problems and at all levels.—Write, stating age, experience and present position, to the Manager, Turbocharger Department, Holset Engineering Co., Ltd., Turnbridge, Huddersfield. E2500 A

WORKS MANAGER
required by
JAMES RESIDE LIMITED, GENERAL ENGINEERS, BRIGHOUSE
Applicants should have production and planning experience of Welded Fabrications and all ancillary machining and fitting operations.
Alert and enthusiastic men should write, giving details and full particulars of experience, qualifications and salary required, to MANAGING DIRECTOR. Only men of proved ability, please.
E2508 A

WORKS MANAGER to take charge of Medium sized specialist fabrication works. Experience in specialised construction of medium and heavy fabrication essential. Application in writing stating qualifications and experience to Box No. E2485 "The Engineer".

SITUATIONS VACANT

ROLLS-ROYCE
LIMITED
have a vacancy for an
ENGINEER
to take technical control of
CHEMICAL PROCESS PLANT
at the
SPADEADAM ROCKET ESTABLISHMENT CUMBERLAND
Applicants should have experience of the control and/or operation of Chemical Process Plant and treatment of domestic and process water supplies, and possess appropriate technical qualifications.
Applications should be made in writing to:—
THE EMPLOYMENT OFFICER (Clke), 17/19 High Cross Street, Brampton, Cumberland.
E7109 A

CHIEF CIVIL ENGINEER

A chief civil engineer is required by one of Great Britain's leading Iron and Steel manufacturers. This is a senior appointment, involving responsibility for all civil engineering aspects of a large development programme. Candidates must have had extensive site, survey and design experience, in the fields of heavy constructional engineering, excavations, earth-moving and quarrying, soil mechanics, foundations, piling, and reinforced concrete work. Experience of this type of work within the iron and steel industry would be an added advantage.

Terms of service and other conditions are attractive and will be discussed fully with candidates selected for interview. One or more assistants to the chief civil engineer may be appointed, and unsuccessful candidates for the senior vacancy will automatically be considered for the offer of appointments as assistants.

Applications will, of course, be treated as confidential, and should be sent to BOX No. E7079, "The Engineer."
A

CIVIL ENGINEERING CONTRACTORS

of international repute require

PROJECT MANAGER

for major contract in West Africa

Applicants should be qualified civil engineers with considerable contracting experience in U.K. and overseas. They should preferably be between the ages of 35 and 50 and should have held positions of responsibility on river works and bridge foundation construction. In addition to being a sound engineer, the selected candidate must be a capable organiser and administrator.

The salary offered is £4000 and good free furnished family accommodation is available. Tours are of 12/18 months duration, after which generous paid home leave is given. The Company pays for transport.

Please write fully and in confidence.—BOX No. E7125, "The Engineer."
A

Classified Advts. continued on page 132

SITUATIONS VACANT

PROFESSIONAL ENGINEERS

are required at the Atomic Energy Research Establishment, Harwell, to take responsibility for the maintenance of high and medium flux reactors in the 6–10MW range and their ancillary equipment. Applicants should have experience of maintenance in electrical, electronic and mechanical engineering fields: experience in installation work or the testing and commissioning of new and prototype equipment would be an advantage.

Salary: £1345–£1800. Housing and superannuation schemes.

Please send a POST CARD for details to the Group Recruitment Officer (5031/25), U.K.A.E.A., A.E.R.E., Harwell, Berks.

E7089 A

TECHNICAL WRITER

Bruce Peebles & Co., Limited, East Pilton, Edinburgh, 5, require a fully experienced Technical Writer. Applicants, age bracket 28–35, should have recognised qualifications in electrical engineering.

The work requires the ability to write lucid descriptions of products and processes covering all aspects of rotating plant, transformers, rectifiers and electronic equipments for publicity, technical press and direct mail. High standards of accuracy and ability to write in clear, concise English are called for. The position will be permanent and staff pension and production bonus schemes are in operation. Assistance with removal expenses and house purchase where necessary.

The man chosen will be under the Publicity Manager, but must be able to work and co-ordinate detailed information without constant supervision.—Send full details of age, education, experience and salary expected to Mr. J. S. Baillie, Publicity Manager, at the above address.

E7039 A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

PLANT MANAGER

for a firm of contractors holding plant, mostly civil engineering, valued in seven figures. The appointment is in the London area and carries responsibility to a director for the efficient operation of the department which employs over 100.

Candidates, age 35-45, should be A.M.I.Mech.E., or equivalent, and have at least 5 years' experience in charge of the provision, working, maintenance and disposal of contractors' plant including heavy civil engineering. Electrical qualifications will be an advantage.

Salary £2250-£2750 plus discretionary bonus: more to a very experienced man. Pension and car or car allowance.

Please send brief details in confidence, quoting reference G.1848, to D. S. A. E. Jessop. In no circumstances will a candidate's identity be disclosed to our client unless he gives permission after a confidential interview at which he will be given full details of the appointment.

MANAGEMENT SELECTION LIMITED,
17, Stratton Street, London, W.1.

E134 A

SITUATIONS VACANT

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

MECHANICAL AND CIVIL ENGINEERING SECTION.

RESEARCH LABORATORIES, LEATHERHEAD.

MECHANICAL ENGINEERS Ref. ENR/319

are required to extend existing research on particular problems under the following broad headings:

(a) The measurement of vibration and its relation to fatigue, particularly in turbines and heat exchangers.

(b) Theoretical and experimental stress analysis.

(c) The static and dynamic characteristics of overhead line conductors and their associated fittings.

Whilst the majority of the work is carried out at Leatherhead, opportunities often arise for the application of techniques developed in the Laboratories to components on site.

Salaries on scales within the ranges £570–£1300 p.a. and £1195–£1775 p.a., according to duties and responsibilities.

Minimum qualifications are a University Degree or H.N.C. in Engineering or Civil Engineering.

Candidates for the more senior posts should have several years' industrial research or development experience.

Applications are also invited from graduates direct from University.

PLANNING DEPARTMENT

STATION PLANNING AND DEVELOPMENT BRANCH

at HEADQUARTERS, LONDON, S.E.1. Ref. ENR/321

ASSISTANT ENGINEERS required in the **Station Planning Section.**

The Section is concerned with the planning of new generating capacity in England and Wales. It is responsible for the investigation and selection of sites for conventional power stations, for the nuclear power stations required to implement the nuclear power programme and for the negotiations for statutory and other consents for both classes of station.

Candidates should possess a Degree or the requisite qualifications for corporate membership of the Institutions of Mechanical, Civil or Electrical Engineers. A sound engineering or scientific background is essential and an aptitude for forward thinking is desirable. It will also be an advantage to have had experience of economic studies, or of one or more of the problems arising in the siting of power stations, e.g. the **thermal and hydraulic** aspects of the use of large volumes of river or sea water for cooling purposes; **ash disposal, fuel transport and reception**; questions of **town and country planning.**

Salaries on a scale within the range £900–£1350 p.a. according to duties and responsibilities.

Applications, stating age, qualifications, experience, present position and salary, to the Personnel Officer, 24/30, Holborn, London, E.C.1, by 1st September. Envelopes should be marked "Confidential," quoting relevant reference number.

E7118 A

PLANT INSPECTION AND CORROSION ENGINEERS FOR BAHRAIN

APPLICATIONS are invited for the above positions from men not over 35 years of age with a University degree in Metallurgy or Mechanical Engineering and preferably previous experience in related work in the Oil Industry.

The duties comprise the inspection of fired and unfired pressure vessels, pumps, heat exchangers, pipe-lines, valves, &c., in service in a modern oil refinery to ascertain their condition and to render reports recommending replacement, adoption of preventive measures and/or new materials necessary to enable the plant to operate continuously in an economical and safe manner.

Salary in accordance with qualifications and experience, with air-conditioned housing provided and an allowance to cover normal meal costs. Kit allowance, free medical attention, paid local and home leaves, pension scheme.

Apply in writing giving full particulars and quoting "INS" to:

CALTEX SERVICES, LIMITED,
CALTEX HOUSE,
KNIGHTSBRIDGE GREEN,
LONDON, S.W.1.

E7049 A

NORRIS CONSULTANTS LTD.,

in view of a two-year expansion programme, require for their London and Bristol Offices and elsewhere in the U.K., Senior and Junior Engineers, Designers and Draughtsmen in the following fields.

CIVIL ENGINEERING DIVISION

Reinforced Concrete, Heating, Ventilating, Air Conditioning, Refrigeration, Pipework and General Services, Structural Steelwork.

PRODUCTION & MECHANICAL DIVISION

Special purpose machines, Transfer Systems, Jigs and Tools, General mechanical, Mechanical Handling, Electrical (Heavy and Light current).

Salary scales up to high level in accordance with age, experience, technical and professional qualifications. Pension and Insurance schemes. Write or telephone Head Office, Beacon House, Queens Road, Clifton, Bristol. Tel.: Bristol 3-6817, or those requiring appointments in London Area, write or telephone: 76, Victoria Street, S.W.1. Tel.: VIC 4675.

E7020 A

TRAINEE ENGINEERING BUYER

An opening occurs for a Trainee Buyer in the Engineering and Standards section of the CENTRAL PURCHASING DEPARTMENT of the DUNLOP GROUP. This section is located at Fort Dunlop, Birmingham, and is responsible for the purchase of plant, engineering materials and tools for overseas factories, and for the co-ordination of engineering procurement and contracts in connection with Company projects.

The successful applicant will have a three months' course of training in Birmingham, and, if satisfactory, will then proceed on an eighteen months' course of instruction at the Group's principal factories. This will include training in matters relating to engineering contracts and procurement, and will be designed to acquaint the trainee with equipment and procedures used by the Company. It will include training with Accounting, Engineering, Insurance, Legal, Shipping and administrative departments.

Applicants should be University Graduate Engineers or equivalent, aged 24-26 inclusive, and should have completed their two years' post-graduate apprenticeship. Those interested are invited to send a letter or postcard asking for a confidential application form, to: STAFF OFFICER (VH), EMPLOYMENT DEPARTMENT, FORT DUNLOP, BIRMINGHAM, 24.

E7091 A

SITUATIONS VACANT

Plessey

CHIEF INSPECTOR

of the Plessey Group of Companies

A key post in an expanding group.

Consequent upon the promotion of the present Chief Inspector to a senior Line Management post a vacancy will arise in the near future for Chief Inspector of the Plessey Company. The Chief Inspector reports directly to a Main Board Director and has functional responsibility for all inspection throughout the Company.

As potential candidates will already know, the product field is extensive, embracing high grade electronic, electrical and mechanical engineering, together with chemical and metallurgical products. Although it is unlikely that the successful candidate will be expert in all these fields, nevertheless, it is necessary that his technical background is such that he is able to assimilate and assess the varied practical problems with which he will be confronted in the product range.

A proportion of the work involved will be in connection with Government contracts. The successful candidate must, therefore, be experienced in working to the high standards which are demanded by Government Inspection Organisations, and fully conversant with procedures in these fields.

The position is regarded by the Board of the Company as of the highest importance and the holder will be remunerated accordingly. Only men already holding senior positions carrying high responsibility need apply.

A Company car or car allowance is provided. There is also a Company Pension/Life Assurance Scheme.

The preferred age is 40 to 45 years, but this should not prevent an outstanding candidate outside this age range from applying for the post.

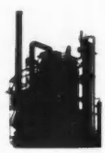
Applications, in confidence, stating age, experience and qualifications, to A. M. Brown, Executive Director (Personnel),

THE PLESSEY COMPANY LIMITED, VICARAGE LANE, ILFORD, ESSEX.

Endorse envelope "Chief Inspector."

E7138 A

SENIOR PROCESS ENGINEER



Vacancy available for Senior Process Engineer at Kellogg International Corporation.

The man who fills this will be responsible for process design of various petroleum, petrochemical and chemical plants . . . Will prepare economic evaluations for various processes. . . . Will maintain considerable liaison with customers both during the initial design and operation of the Units.

A degree in Chemical Engineering with 8–10 years' diversified experience in process design and operations in the petrochemical or petroleum industries are minimum requirements. This man will be an engineer of high technical ability with a good personality.

This is a challenging job which will appeal to a hard-working and ambitious engineer, carries a salary commensurate with the responsibilities involved. Personnel benefits include contributory pension and life insurance scheme, luncheon vouchers, etc. Holiday commitments for this year will be honoured.

APPLY BY LETTER TO PERSONNEL MANAGER,

KELLOGG

INTERNATIONAL CORPORATION

7–10 CHANDOS STREET, CAVENDISH SQUARE, LONDON, W.1.

(Please quote reference 144/G.)

E7114 A

SMITHS MOTOR ACCESSORY DIVISION

Senior Designer—Mechanical
Senior Development Engineer

These two vacancies exist in the Division's Product Development Department in London for men with the following qualifications :—

A.M.I.Mech.E., though a good H.N.C. in Mechanical Engineering might suffice ; at least 5 years' Design-Development experience of precision mechanisms for mass production, together with apprenticeship or equivalent training ; age range 30–40.

Applicants who can command a good four-figure salary and who seek a position with prospects should write to

The Staff Manager,

S. SMITH & SONS (ENGLAND) LIMITED

Cricklewood, N.W.2.

quoting reference SM/225.

E7144 A

MECHANICAL HANDLING

Project and Production

DESIGNERS

with extensive experience on Bulk Material Handling Plant and Equipment required by well-known progressive Company in the North Midlands, serving Coal, Quarry, Oil, Gas and Chemical Industries.

The men we are looking for will be first and foremost Structural Designers used to Stress work, coupled with familiarity with designs of Crushing, Screening, Conveying and Bulk Handling of Materials and Fluids.

They will be at least H.N.C. standard, will have initiative and already be earning in the region of £900/£1000.

Applicants with proved ability will be invited for early interview for which expenses will be paid.

Write, giving full chronological details of experience, &c.—BOX No. E7107, "The Engineer."

A

SITUATIONS VACANT

DRAUGHTSMEN

SENIOR AND JUNIOR DRAUGHTSMEN

are required for original and interesting work on marine nuclear propulsion machinery installation.

Applications are invited from suitably qualified Engineering Draughtsmen having held responsible posts in Drawing-Office procedure and Contracts work. Marine experience is essential. There are also a few vacancies for Juniors interested in this particular field.

A modern Drawing-Office, pleasantly situated on the South Coast forms a further inducement to enter a new field presenting a constant challenge to ingenuity and design. Salary will be in accordance with age, experience and qualifications.

Please write with full particulars to :

The Manager,

VICKERS-ARMSTRONGS (ENGINEERS), LTD., Oak Yard, Hazel Road, Itchen, Southampton

E7090 A

Lloyd's Register of Shipping

(Land Division)

now occupying new offices at

EAST CROYDON

have vacancies for

TECHNICAL ASSISTANTS

with Higher National Certificate and Mechanical Engineering background. Experience in pressure vessel design desirable but not essential. Candidates of promise with lower technical qualifications may be considered.

Commencing salary according to age and qualifications.

Apply, Secretary, Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C.3.

E7105 A

A CHARTERED ELECTRICAL ENGINEER

required by

W. H. ALLEN SONS & Co., LTD.

Queens Engineering Works, Bedford

To undertake commercial work involving the preparation of tenders for a.c. and d.c. machines, control gear and switchgear, for marine and industrial applications, including water undertakings.

Some experience as outside representative desirable.

Preferred age range 30–40 years.

Applications in writing to : the Personnel Manager.

E7053 A

SITUATIONS WANTED

MECHANICAL ENGINEER (30) seeks responsible position, small firm, or will undertake Mechanical Project under contract. University education, food research and design experience and SPECIALIST KNOWLEDGE HIGH-SPEED PAPER HANDLING. North London/Herts.—BOX No. E2505, "The Engineer." B

WORKS OR PRODUCTION ADMINISTRATIVE AND SKILLED ENGINEER requires position. Age 47. Experience Work Study, Standard Costs, Planning, Tooling, Works and Production Control. Technical qualifications.—BOX No. E2513, "The Engineer." B

BUSINESSES and PREMISES

INDUSTRIAL ACCOMMODATION Light Engineering Storage 5000 super with Office Block and 8000 super. All services including Private road, Car Park, near Great South West Road. Reasonable rental.—Macks Structures (London), Ltd. Feltham 5761. E2504 L

MALDON, ESSEX. New single-storey factory just completed near town centre. Net floor space 6000 square feet. Good access from service road with two entrances and rear yard. Additional land for extension if required. All services. Price £11,000 freehold.—Apply Estate Manager, 18, Upper Brook Street, W.1. E7117 L

FOR HIRE

BELLMANS MASTS FOR HIRE, to lift from 1 to 20 tons, 30ft. to 150ft. Blocks and tackle. Hand-operated winches. From £1 per day.—BELLMAN'S (Phone : SLOane 5259), Hobart House, Grosvenor Place, S.W.1. E103 K

BUSINESS OPPORTUNITIES

TO MEDIUM/LARGE FIRMS with capacity available for Light Aluminium Pressings. Advertiser has proposition which could load your works to capacity. The product has not been on the market before in this form and would be in continuous demand. A Royalty on a percentage profits basis would be required. Principals only, please.—BOX No. E2506, "The Engineer." O

REMPLOY SPONSORSHIP SCHEME.—Send for details which show an attractive proposition to manufacturers.—Write to the Managing Director, Remploy, Ltd., 25–28, Buckingham Gate, S.W.1, or telephone VICtoria 6621 (12 lines). E155 O

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved. —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

PATENTS

THE TRADE MARKS set out below were assigned on 31st March, 1959, by Foxboro-Yoxall, Ltd., of Redhill, Surrey, to The Foxboro Company, of Foxborough, Massachusetts, United States of America, WITHOUT THE GOODWILL OF THE BUSINESS IN WHICH THEY WERE THEN IN USE.

Registered No.	Trade Mark	Goods
688991	AIRDRON	Pressure regulators (being parts of machines)
688996	CONSOTROL	Pneumatically operated apparatus for controlling the functioning of manufacturing plant
688997	FLINTEX	Procelain tubes for pyrometers
688988	PYOD	Thermo-electric couples for pyrometers
688999	LAUNDERLOG	Combined thermometers and liquid level gauges
705080	FOXBORO STABIFLO	Pneumatically operated valves for use in pipeline systems
705081	FOXBORO VERNIER VALVACTOR	Pneumatically operated instruments for controlling the action of valves in pipeline systems

E7086 H

PATENT No. 748164—Improvements in or relating to the Control of Sequentially Operated Multi-Unit Apparatus such as Dust Recovery Plant.

The Proprietors of Patent No. 748164 desire to enter into arrangements by way of Licence or otherwise on reasonable terms, to ensure its full development and commercial working in this country.

Address enquiries to :—
W. P. Thompson and Co.,
Chartered Patent and Trade Mark Agents,
12, Church Street,
LIVERPOOL, 1.

E7108 H

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Classified Advts. continued on page 134

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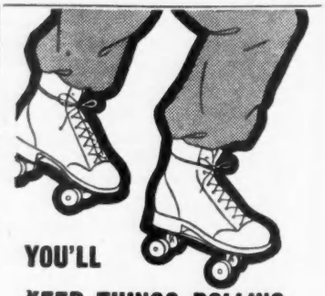

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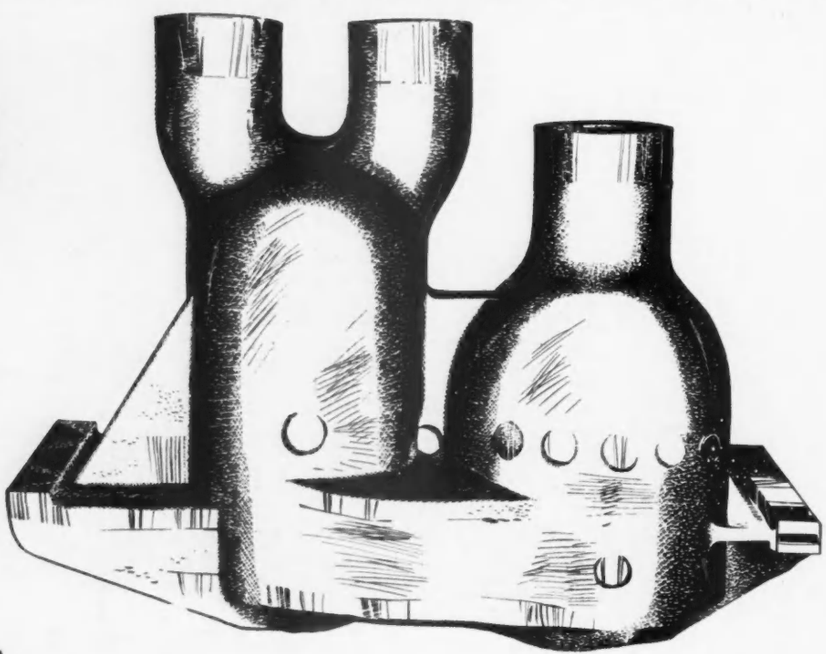

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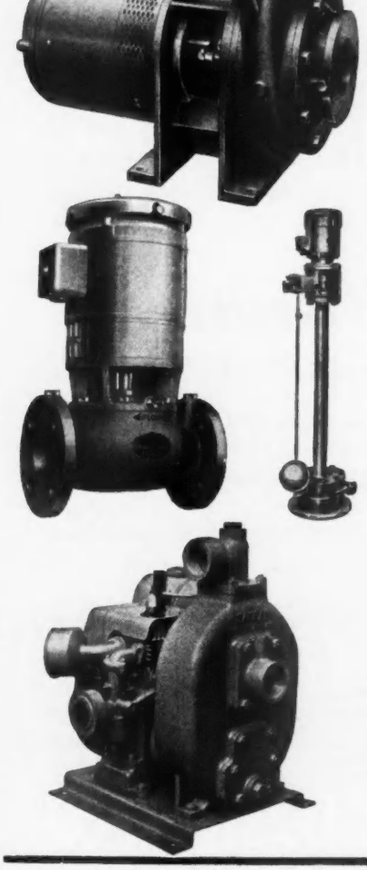

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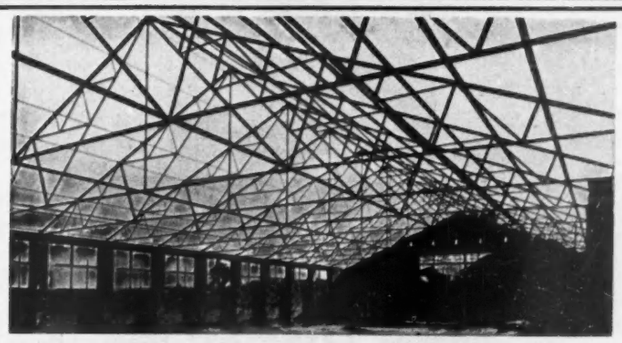

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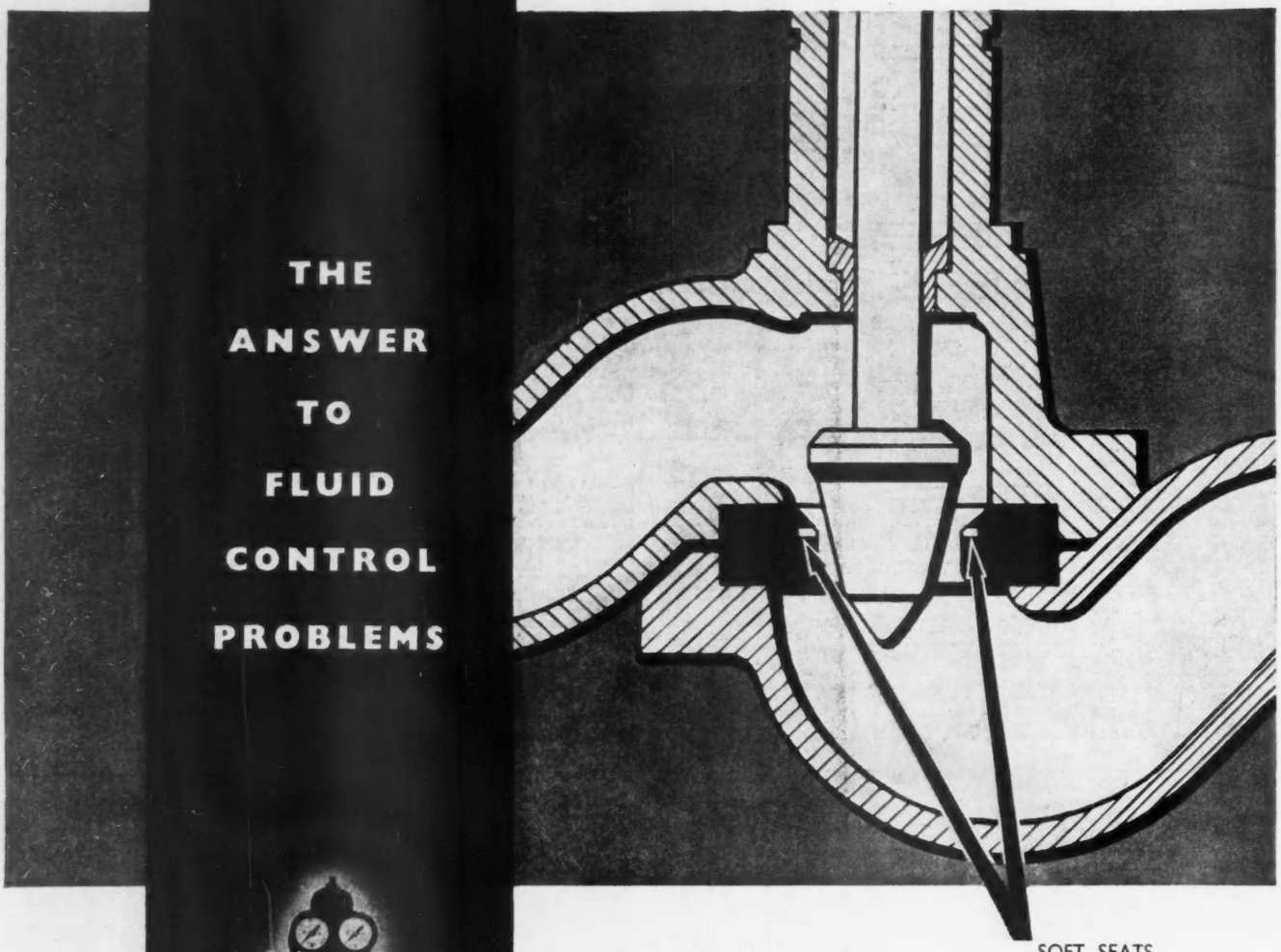

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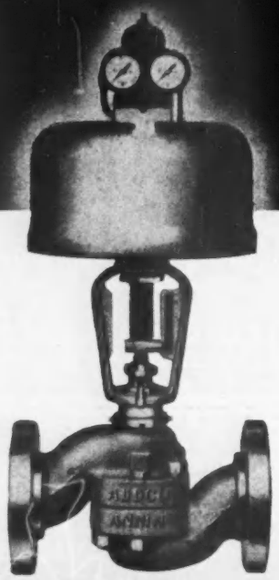

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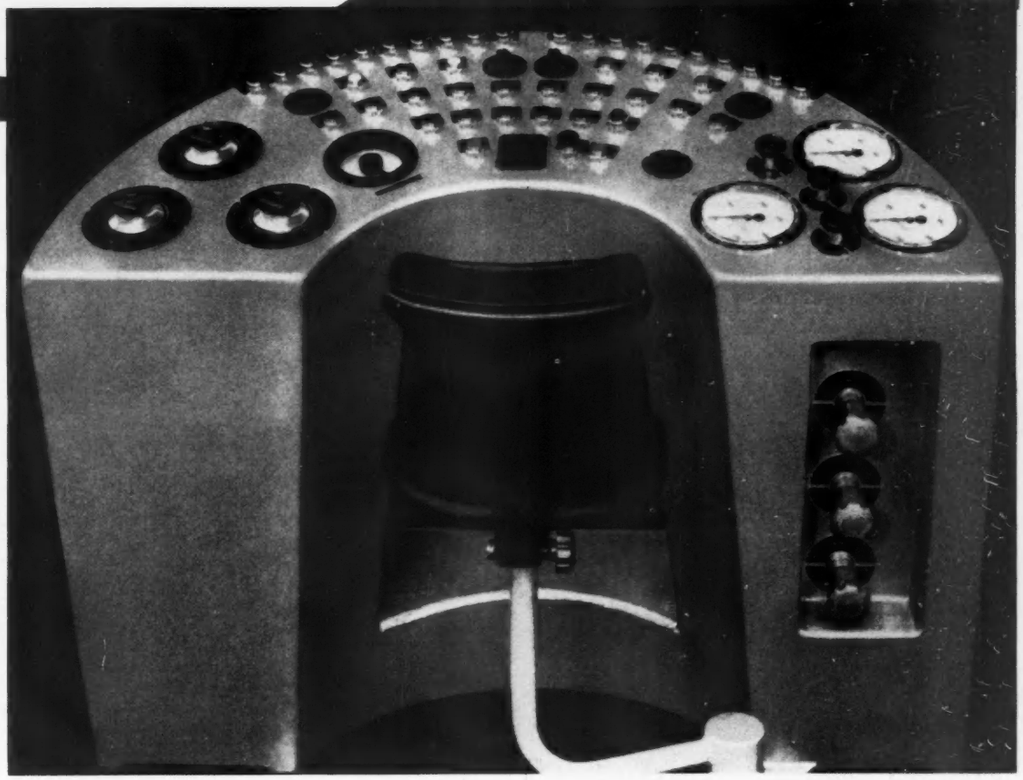

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